San Luis Obispo County

Coastal Regional Sediment Management Plan

Prepared for:

THE CALIFORNIA COASTAL SEDIMENT MANAGEMENT WORKGROUP

Prepared By:

US ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT
SAN LUIS OBISPO COUNCIL OF GOVERNMENTS
EVEREST INTERNATIONAL CONSULTANTS, INC.
MERKEL & ASSOCIATES, INC.
PHILIP KING, PHD

US Army Corps of Engineers

SLOCOG
SAN LUIS OBISPO COUNCIL OF GOVERNMENTS

EVEREST

Blank
Page

FIGURES

TABLES

BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BOEM	Bureau of Ocean Energy Management
BRRG	CSMW Beach Restoration Regulatory Guide
Caltrans	California Department of Transportation
CAR	Coordination Act Report
CARB	California Air Resources Board
CCA	California Coastal Act
CCC	California Coastal Commission
CCD	Coastal Consistency Determination
CDFW	California Department of Fish and Wildlife
CDP	Coastal Development Permit
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CGS	California Geological Survey
CH	Critical Habitat
CLEAP	Comparative Lagoon Ecological Assessment Project
CMS	US Army Corps of Engineers Coastal Modeling System
CRSM	Coastal Regional Sediment Management
CRSMP	Coastal Regional Sediment Management Plan
CSBAT	Coastal Sediment Benefits Analysis Tool
CSLC	California State Lands Commission
CSMW	Coastal Sediment Management Workgroup
CSP	California State Parks
CWA	Clean Water Act
CZMA	United States Coastal Zone Management Act
DBW	Division of Boating and Waterways
DMMP	Dredged Material Management Plan
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENSO	El Niño Southern Oscillation
ESA	Endangered Species Act
FE	Federal Endangered Species
FONSI	Finding of No Significant Impact
FP	State of California Fully-Protected Species
FT	Federal Threatened Species
GHAD	Geologic Hazard Abatement District
GIS	Geographic Information System
HCP	Habitat Conservation Plan
IWR	USACE Institute for Water Resources

JPA	Joint Powers Authority
LCP	Local Coastal Program
LiDAR	Light Detection and Ranging
MBNMS	Monterey Bay National Marine Sanctuary
MBTA	Migratory Bird Treaty Act
MHHW	Mean Higher-High Water
MHW	Mean High Water
MLLW	Mean Lower-Low Water
MLW	Mean Low Water
MMPA	Marine Mammal Protection Act
MND	Mitigated Negative Declaration
MOU	Memorandum of Understanding
MP	Master Plan
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MTL	Mean Tide Level
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
ND	Negative Declaration
NED	National Economic Development
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization
NMFS	NOAA National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf Lands Act
PBR	Public Beach Restoration
PCWQCA	Porter-Cologne Water Quality Control Act
PDO	Pacific Decadal Oscillation
PEM	Pressure Equalization Module
Plan	Coastal Regional Sediment Management Plan
RLF	Resource Legacy Fund
RSM	Regional Sediment Management
RWQCB	Regional Water Quality Control Board
SAA	Streambed Alteration Agreement
SAG	Stakeholder Advisory Group
SANDAG	San Diego Association of Governments
SB	State Beach
SCC	California State Coastal Conservancy
SCOUP	Sand Compatibility and Opportunistic Use Program
SE	State of California Endangered Species
SICH	Sediment Impaired Coastal Habitat
SIP	Strategic Implementation Plan
SLOCOG	San Luis Obispo Council of Governments

SLR	Sea level rise
SP	State Park
SSC	State of California Species of Special Concern
ST	State of California Threatened Species
SWPPP	Storm Water Pollution Prevention Plan
TOT	Transient Occupancy Tax
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDR	Waste Discharge Requirement

EXECUTIVE SUMMARY

ES 1. Introduction

This San Luis Obispo County Coastal Regional Sediment Management Plan (CRSMP) was developed for the California Coastal Sediment Management Workgroup (CSMW) by the United States Army Corps of Engineers (USACE) in partnership with Everest International Consultants and the San Luis Obispo Council of Governments (SLOCOG). The CSMW is a collaborative effort of federal, state, and local agencies and non-governmental organizations committed to evaluating and addressing California's coastal sediment management needs on a regional basis. Established in 1999, the CSMW is co-chaired by the USACE South Pacific Division and the California Natural Resources Agency (CNRA). Its creation was a response to concerns – raised by the state, representatives of local governments, USACE, and environmental groups – about the piecemeal identification of problems and implementation of site-specific solutions that did not effectively address critical problems along the coastline.

A CRSMP (Plan) frames policy and guidance strategies to restore, create, and maintain coastal beaches and other critical areas of sediment deficit; sustain recreation and tourism; enhance public safety and access; restore coastal sandy habitats; and identify cost-effective solutions for restoration of areas of excess sediment. This Plan, which covers the coastal shoreline and environs of San Luis Obispo County (Figure ES-1), focuses on coastal stretches where mitigating existing and expected future coastal erosion and other co-objectives – e.g., ecology, recreation, and protection of property and infrastructure – is or will be crucial. Increased sediment supply contributes to wider beaches and hence can mitigate coastal erosion while providing additional benefits. These benefits potentially include reduced risk of damage to property and development, sustained beaches and their ecology, and maintained and enhanced recreation. The Plan supports the desire to identify regional approaches that are often more effective, less costly, and easier to fund than local efforts.

The foundation of this Plan is existing information gathered and integrated into a geographical information system (GIS) data base. Available information includes the geology, geography, ecology, development, and property within the Plan area. Coastal erosion rates, locations of high coastal erosion, and associated vulnerable assets were identified using prior studies and other available data.

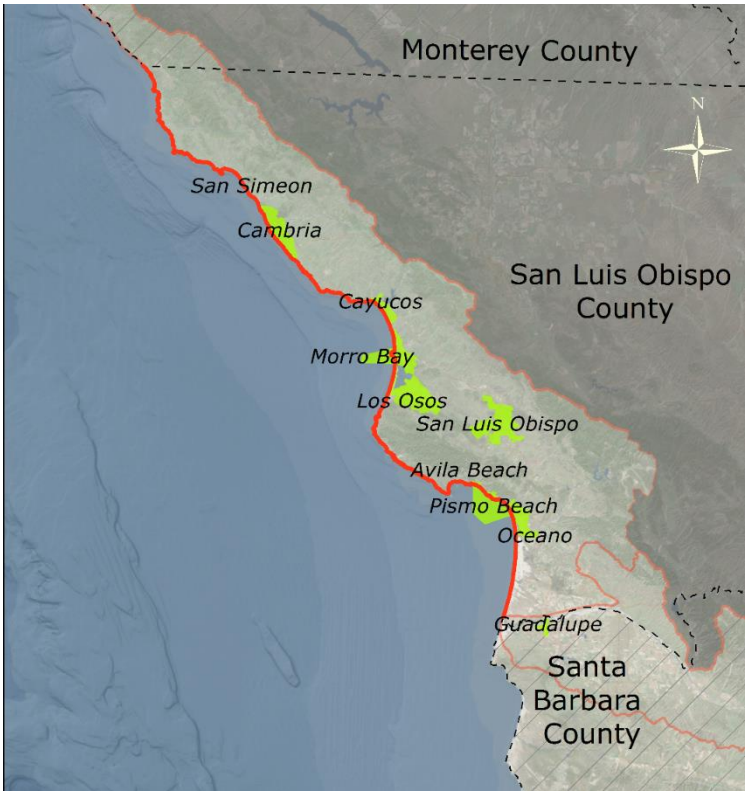


Figure ES-1. San Luis Obispo County Plan
(coastline in red, county lines dashed, and watershed boundaries in orange).

ES 2. Setting

The coastline covered by this Plan extends approximately 96 miles from the Monterey County line to the Santa Barbara County line. It comprises the coastal watersheds, coast, and nearshore (Figure ES-1). The area includes a number of popular recreational beaches, two harbors (Morro Bay and Port San Luis), and a large dune field ranging from the Pismo Dunes through the Guadalupe Dunes. The coastline is broken into a variety of landforms – e.g., sand and cobble beaches, rocky intertidal areas, rocky bluffs, and loosely consolidated bluffs.

San Luis Obispo County includes a wide variety of beaches (Table ES-1) ranging from large, highly attended beaches – e.g., Pismo Beach and Morro Bay – to secluded and undeveloped pocket beaches visited rarely and by only the most dedicated wilderness enthusiasts.

Table ES-1. Beaches of San Luis Obispo County

#	Beach Name
1	Ragged Point – San Carpoforo Creek
2	Ragged Point – Breaker Point
3	Point Sierra Nevada
4	Arroyo de la Cruz
5	Arroyo del Corral
6	Point Piedras Blancas
7	W.R. Hearst Memorial State Beach (San Simeon Bay)
8	Little Pico Creek
9	Pico Creek
10	San Simeon Creek
11	Moonstone Beach and Leffingwell
12	Santa Rosa Creek
13	Fiscalini to Lampton
14	Harmony Headlands State Park (aka Nikki's Beach)
15	China Harbor
16	Estero Bluffs State Park, Villa Creek
17	Cayucos State Beach
18	Toro Creek / North Point
19	Morro Strand State Beach
20	Morro Rock City Beach
21	Beaches within Morro Bay
22	Morro Bay State Park / Morro Dunes Natural Preserve
23	Montaña de Oro State Park
24	Point San Luis to Olde Port Beaches
25	Avila Beach
26	Pirate's Cove
27	South Palisades Park
28	Shell Beach
29	Pismo State Beach
30	Oceano Dunes
31	Guadalupe-Nipomo Dunes

The San Luis Obispo County coastline can be divided by many possible features, of which the physical process of sand transport seems most appropriate for a CRSMP. These physical processes are most easily described by a sand-volume accounting system called the sediment budget and a geographical grouping method based on the concept of a littoral cell. The sediment budget approach was developed to understand the impact of coastal processes on shoreline change. The sediment budget conceptually accounts for inflows (sources), outflows (sinks), and storage of sediment within a littoral cell. A littoral cell is a coastal compartment or physiographic unit that contains sediment sources, transport paths, and sediment sinks (Patsch and Griggs, 2007). A *littoral cell* is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks. In general, sand does not enter or leave the compartment in either the upcoast or downcoast direction. Most cells, however, are not absolutely separated and do have some sediment leakage between them.

The northern portion of coastal San Luis Obispo County is occupied by the Morro Bay Littoral Cell ([Patsch and Griggs, 2007]; also called the Estero Bay Littoral Cell by Dingler et al, [1982]). The southern portion is covered by the Santa Maria Littoral Cell (DNOD, 1977; SIO, 2004). Some consider the Santa Maria Littoral Cell to be a sub-cell within the Santa Barbara Littoral Cell (Patsch and Griggs, 2007). Within the context of this Plan, however, reference will only be made to the Santa Maria Littoral Cell. These littoral cells are shown graphically in ES-2.

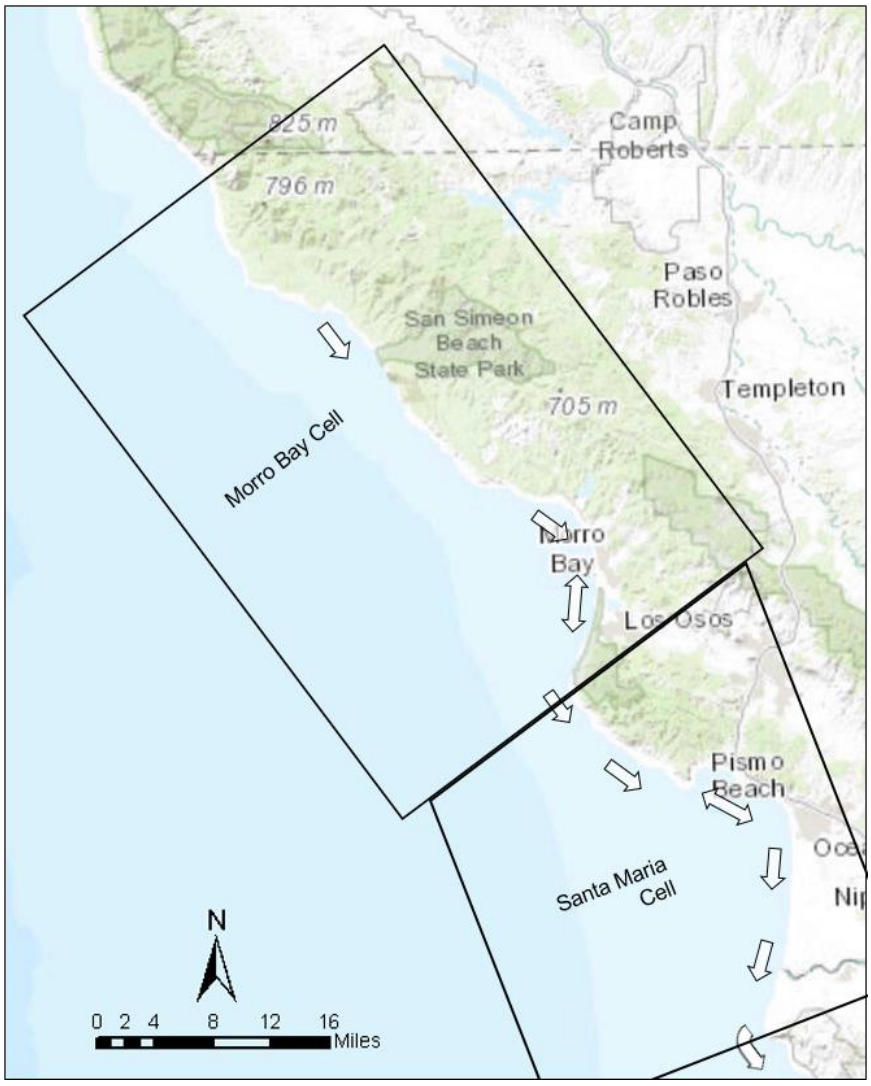


Figure ES-2. Morro Bay and Santa Maria Littoral Cells.

Each littoral cell has distinct sediment management problems and opportunities that must be addressed in the context of a region-wide understanding of sand supply, transport, and erosion. In addition, it is anticipated that future sea level rise will exacerbate beach erosion, particularly in areas where the position of the backshore has been fixed by armoring.

Morro Bay Littoral Cell

As with the rest of the San Luis Obispo coast, net sediment transport occurs in a southerly direction (southeast along the coastline), with significant temporary reversals depending on changes in the wave

climate, which are typically associated with seasonal weather patterns. Morro Bay constitutes a notable discontinuity in the sediment transport, as the bay entrance intercepts approximately 115,000 cubic yards per year (yd^3/yr) of sediment. Significant onshore sediment transport (sink) occurs at the southern end of the littoral cell through aeolian processes.

Santa Maria Littoral Cell

The Santa Maria Littoral Cell extends either from Point Buchon (SIO, 2004) or from Point San Luis (DNOD, 1977) terminating in the south at Point Sal. Quantitative sand components for this littoral cell are from Bowen and Inman (1966), except where stated otherwise. Significant onshore sediment transport (sink) occurs at the southern end of the littoral cell through aeolian processes.

Wave Climate

The wave climate changes daily, weekly, monthly, and seasonally, which results in complex changes at the coast. Waves of varying periods, size, and approach direction affect different parts of the San Luis Obispo County littoral cells depending on coastline orientation. Most wave energy approaches from the northwest and west, often in the form of swell generated by extratropical cyclones and cold fronts in the North Pacific (Storlazzi and Wingfield, 2005). This swell, which tends to peak in size and period during the winter months, is responsible for the largest waves. Additional wave energy from the northwest approaches the coast in the form of wind waves, which occur most frequently between April and October when the California high-pressure system generates northwesterly winds (Storlazzi and Wingfield, 2005).

Waves also approach from the south and southwest, although this occurs with less frequency and intensity than the North Pacific swell (Storlazzi and Wingfield, 2005). In the summer months, strong storms in the southern hemisphere generates swell that can reach most of the coast. Winter storms may also generate local wind waves, which can propagate in a wide range of directions depending on the storm's track. When taken together, the predominant wave energy approaches the cell from the northwest, and the scientific consensus is that the net direction of sediment transport is from the northwest to the southeast (Patsch and Griggs, 2007).

Changes in Sea-Level

Although there is strong consensus that sea-level is expected to rise in the future, there is still considerable uncertainty regarding the magnitude of this rise, with differences of over several feet between high and low scenarios predicted by the National Research Council (NRC [Figure ES-3)). As a result, the federal government, specifically USACE, is incorporating this uncertainty in into its missions by evaluating how a number of sea level scenarios would affect future coastal projects (USACE, 2013). The NRC completed a region-specific assessment of sea level rise data for the U.S. West Coast, which includes a comprehensive overview of region-specific factors (climate, tectonics) that influence sea-level change along the California coast (NRC, 2012).

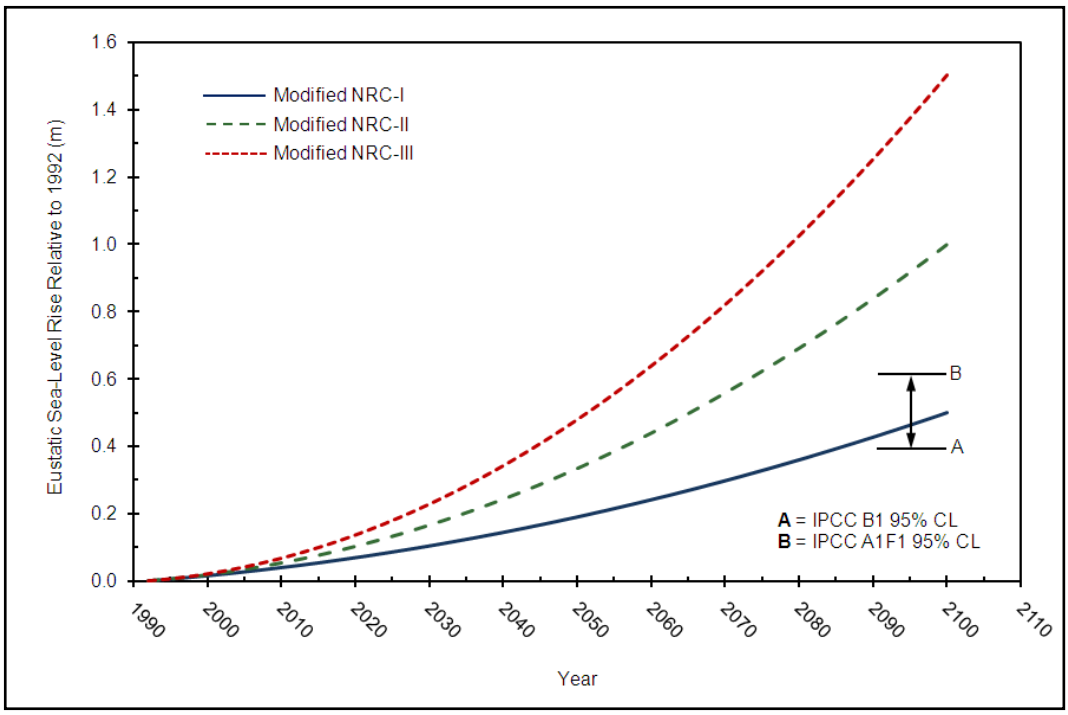


Figure ES-3. Modified NRC (1987) global mean sea level rise scenarios and the Intergovernmental Panel on Climate Change (2007) scenario. Source: USACE (2011)

ES 3. Sediment Sources, Coastal Erosion, and Receiver Sites

Sediment Sources

Potential upland, coastal, nearshore, and offshore sediment sources exist for nourishment projects within San Luis Obispo County. Although some sediment quantity and grain size characteristics of these sources are known, information regarding material properties, timeframe of their availabilities and transport costs varies and continually changes depending on project-specific characteristics. The lists of potential sediment sources can be expanded depending on project preferences and as more information becomes available.

Upland sources include dams and reservoirs, known or anticipated construction sites with an excess of sandy material to be removed, and sand mining operations. Coastal and nearshore sediment sources include harbor and marina maintenance dredging projects (including bypassing and backpassing across harbor entrances, such as Morro Bay), wetland restoration and maintenance dredging projects, and river maintenance dredging projects. Offshore sediment sources generally consist of relic sand deposits, but these have not been comprehensively mapped for San Luis Obispo County.

Coastal Erosion Sites

Developed areas of the San Luis Obispo coast which are important to tourism and other aspects of the county's economy are mostly limited to five locations: Cambria/Moonstone, Cayucos, Morro Bay, Port San Luis/Avila Beach, and Pismo Beach. Although specific examples of erosion problems inside San Luis Obispo County exist and should be considered, it should be noted that most of the county's shoreline is either protected from development (e.g., state parks and beaches), or else privately owned,

often by agriculture. Thus, there is little development or infrastructure compared to other counties such as those in the south. Flooding and erosion at these undeveloped beaches is usually not a threat to infrastructure or recreational beaches so natural processes continue without concern. Where historical erosion or flooding has occurred in the past is discussed below. Future sea level rise induced erosion or flooding is also discussed, where applicable. Historical flooding sites that are not relevant to coastal sediment management have not been identified. There are, however, coastal erosion sites that are discussed below.

The CSMW WebMapper shows shoreline erosion rates along the coast as calculated by Hapke et al. (2006), over the period from 1942 to 2002. There were no areas with erosion greater than 3 feet identified within San Luis Obispo County. Erosion between 0 to 3 feet was common at places such as Cayucos, Morro Strand State Beach, Morro Bay State Park, Montaña de Oro State Park, Shell Beach, Pismo Beach, and Oceano Dunes. This historical erosion is neither necessarily significant nor indicative of future conditions. Areas with noted or observed beach erosion are shown in Table ES-2.

Table ES-2. Coastal Erosion Sites

Site	Need for Beach Nourishment	Description	Source	Threatened Infrastructure
Piedras Blancas Realignment	No	Bluff erosion threatens highway. Realign 2.8 miles of State Route 1 inland away from eroding bluffs.	Caltrans 2010a, 2010b	Road
Hearst San Simeon State Park	Not stated	None stated	Higgins, et al., 2004	Road
Cambria	Not stated	Bluff erosion threatens residential properties. Many seawalls and riprap exist.	Griggs et al, 2005	Residential properties
Cayucos	Possible	Inadequate protection of commercial area from storm waves and coastal flooding. Passive erosion of beach.	Higgins et al., 2004; Griggs et al, 2005; Surfrider Foundation, 2014	Parking, roads, businesses, residential property, beach
Shell Beach - St. Andrews Lift to Price Street	No	Erosion of steep bluff. Damage to lift station. Structural bluff protection likely	USACE, 2014b	Road, residential property, sewage lift station
Shell Beach - Price Street Pocket Beach	Yes	Street threatened by erosion of steep bluff.	CSMW, 2002	Road
Pismo Coast Village RV Resort	Yes	Damage from flooding and storm waves. Erosion threatens bluffs and overlook	Coastal San Luis Resource Conservation District, 2011	RV Resort

Receiver Sites

There are several historical and potential sediment receiver sites (e.g., nourishment or placement sites) in the San Luis Obispo County coastal zone. Some of these receiver sites are erosional hot spots and future flooding locations while others are simply sites convenient for beneficial use of dredged material.

Sea Level Rise Adaptation

There are numerous areas in San Luis Obispo County that will likely be susceptible to sea level rise induced flooding or erosion as described in Section 3.3 of this report. At this time, it would be premature to conclude that nourishment would be an appropriate solution. For example, sea level rise induced flooding is expected at the floodplains for Cayucos, San Luis Obispo, Pismo, and Arroyo Grande creeks, but nourishing the associated beaches and raising the beach berm may only serve to exacerbate fluvial flooding. A detailed study is needed at each location to assess possible risks, costs, and benefits associated with sea level rise adaptation strategies.

ES 4. Regional Sediment Management Measures

A management measure is a strategy or activity that could be implemented at a specific geographic site to address one or more planning objectives. Management measures are the building blocks of alternative plans and are categorized as non-structural and structural. Non-structural measures reduce risk by modifying the characteristics of the buildings and structures that are subject to the effects of erosion or modifying the behavior of people living in or near potential erosional areas. Structural measures reduce risk by modifying the characteristics of the erosion. Coastal communities have a number of options in dealing with coastal erosion. The California Coastal Commission's (CCC) Sea Level Rise Guidance Document (2015) lays out a number of options, none of them mutually exclusive (Figure ES-4).

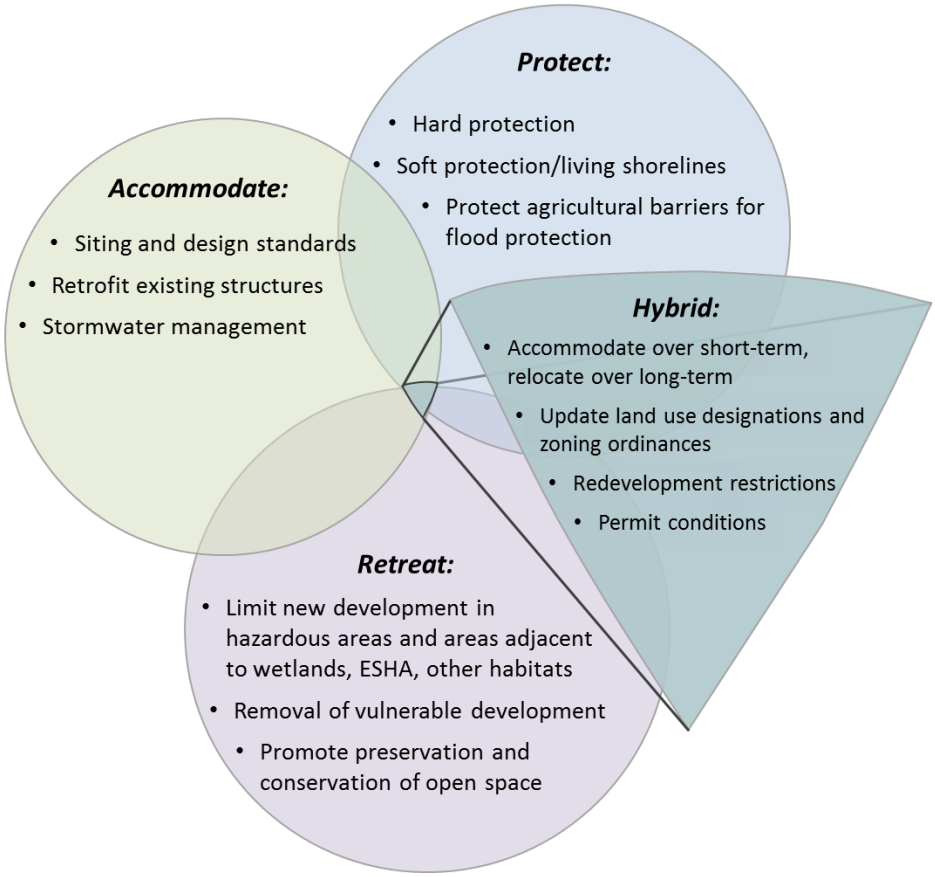


Figure ES-4. Strategies for Adapting to Sea Level Rise.

With regard to coastal erosion, measures are often employed to reduce or refocus wave energy, direct water away from damageable property, or protect infrastructure. Table ES-4 lists the measures deemed appropriate for erosion response along the San Luis Obispo coastline, but there are others that might be appropriate in specific areas.

Table ES-4: Regional Sediment Management measures considered in the Plan

MEASURE	DESCRIPTION
No Action	This approach assumes that the "status quo" will continue over the next 50 years, often with local interests maintaining existing erosion control measures.
Shoreline Protection and Armoring	This measure involves using hard structures (e.g., seawalls, groins, and revetments) to prevent bluff and beach erosion.
Setbacks	Construction and development setbacks can reduce the need for coastal protection, armoring, and nourishment. The setback should be based on a local bluff or coastline erosion rate determined by geologic engineers applied over a 100-year structure life.
Beach Nourishment	This measure involves the direct placement of sand on the sub-aerial beach or in the shallow waters of the surf zone.
Nearshore Nourishment or Placement	This measure differs from direct beach nourishment in that sediment is placed in nearshore waters, often at depths of up to 30 or 40 feet.

Sand Compatibility and Opportunistic Use Program (SCOUP)	Opportunistic use of beach-quality sand from local construction projects makes use of material that otherwise would be disposed of in a landfill or as construction fill.
Stockpiling	Temporary storage of sediment can increase the flexibility of an opportunistic source by both reducing costs and extending timelines. Once a receiver site becomes available, the stockpiled material can be moved to where it is needed.
Sand Retention: Artificial Reef	Artificial reefs are sand retention devices that may be compatible with permitting agencies, improve recreational opportunities, and increase hard-bottom habitat.
Sand Retention: Dewatering	Beach-face dewatering is the lowering of groundwater within the beach to increase natural accretion processes.
Sand Retention: Soft Solutions	This measure involves sand retention approaches that are not constructed of rock or concrete (e.g., beach planting, geotextile sand-filled bags).
Managed Retreat	This measure involves relocating development and infrastructure away from coastal erosion hazard zones.

ES 5. Biological Resources

The San Luis Obispo County nearshore zone includes part of the Monterey Bay National Marine Sanctuary (MBNMS) and several managed areas and protected habitats including State Marine Conservation Areas (SMCA), State Marine Reserves (SMR), State Marine Recreational Management Area (SMRMA), state parks and beaches, and state game refuges. It also includes ecologically significant habitats where endangered or threatened species may occur, designated critical habitat, nesting sites, foraging areas, or over-wintering areas. In addition, major haul-out or roosting areas of fully protected species or important nursery or spawning areas of state-managed fishery species are also are considered sensitive biological resources. The county hosts a variety of species, including more than ten species of cetaceans (whales, dolphins and porpoises), four species of pinnipeds (seals and sea lions), otters, numerous fish species, and resident birds. Being located on the Pacific flyway, it also serves as a temporary home to several migratory birds.

Coastal sediment management options, such as beach nourishment and the construction of sediment retention structures, have the potential to affect habitats and species in the littoral cells in a variety of ways. In addition, removing sand from aquatic and upland sources also has the potential to adversely affect biological resources in the vicinity. Many of the biological and natural resources are protected by various federal and state environmental laws and regulations. As such, compliance with these environmental laws and regulations is required prior to undertaking sediment management activities.

For purposes of discussion, coastal San Luis Obispo County was divided into four regions: North, North-Central, South-Central, and South. Figure ES-5 through Figure ES-9 provide details of the habitats within each region, including: shore type (i.e., sandy beach, rocky shore, hardened or

constructed shorelines); managed and protected areas (e.g., SMCA, SMR, state parks, reserves); coastal rivers and streams; kelp canopies; estuaries; and critical habitat. Four additional "detail" figures at select locations across the coastal county have been prepared and are available in Section 5.1; for convenience and example, the detail figure for Morro Bay is also presented as Figure ES- 8. All spatial data will be available for viewing on the CSMW website (CSMW, 2015) once this CRSMP has been finalized.

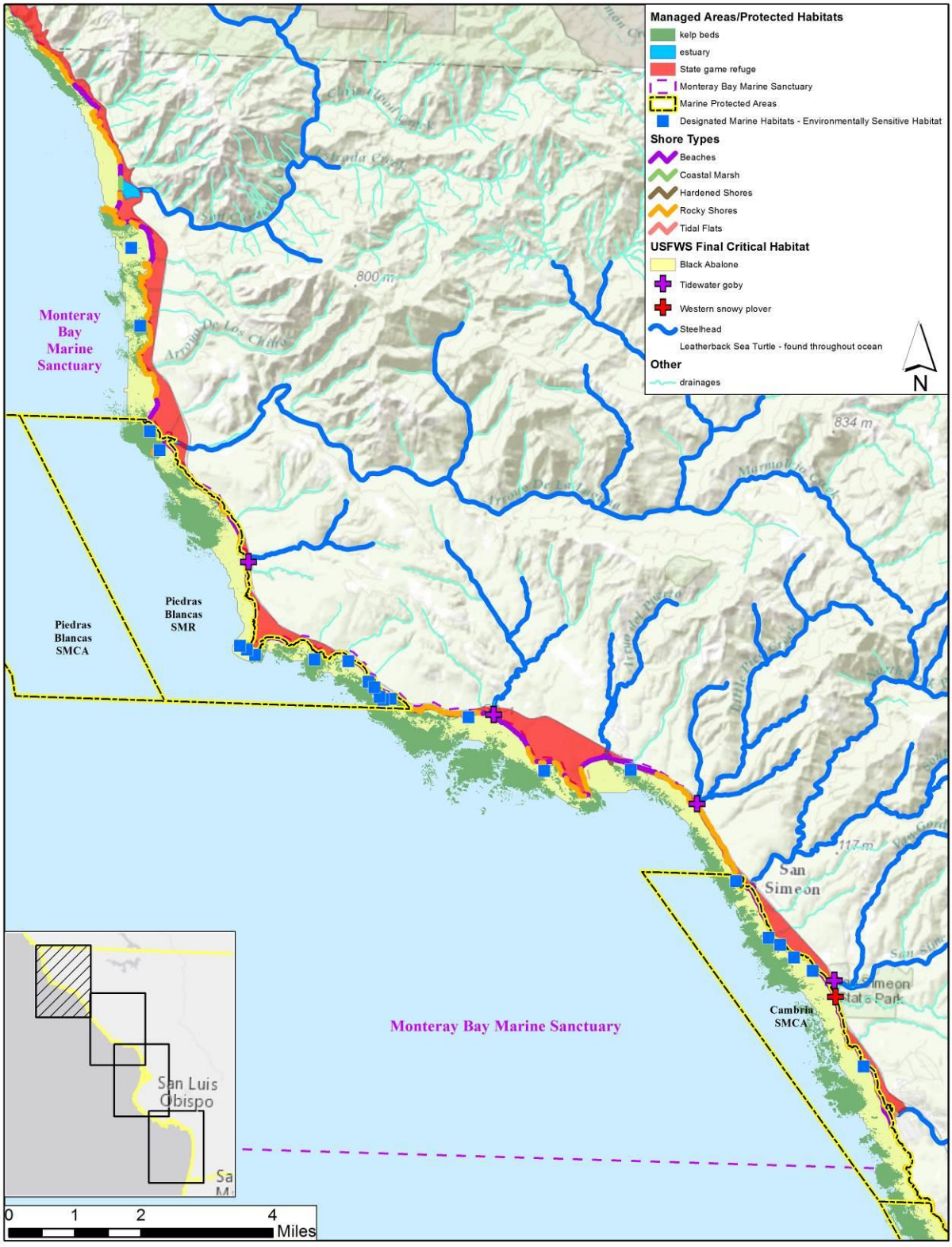


Figure ES-5. North San Luis Obispo County Biological Resources.

Figure ES-6. North-Central San Luis Obispo County Biological Resources.

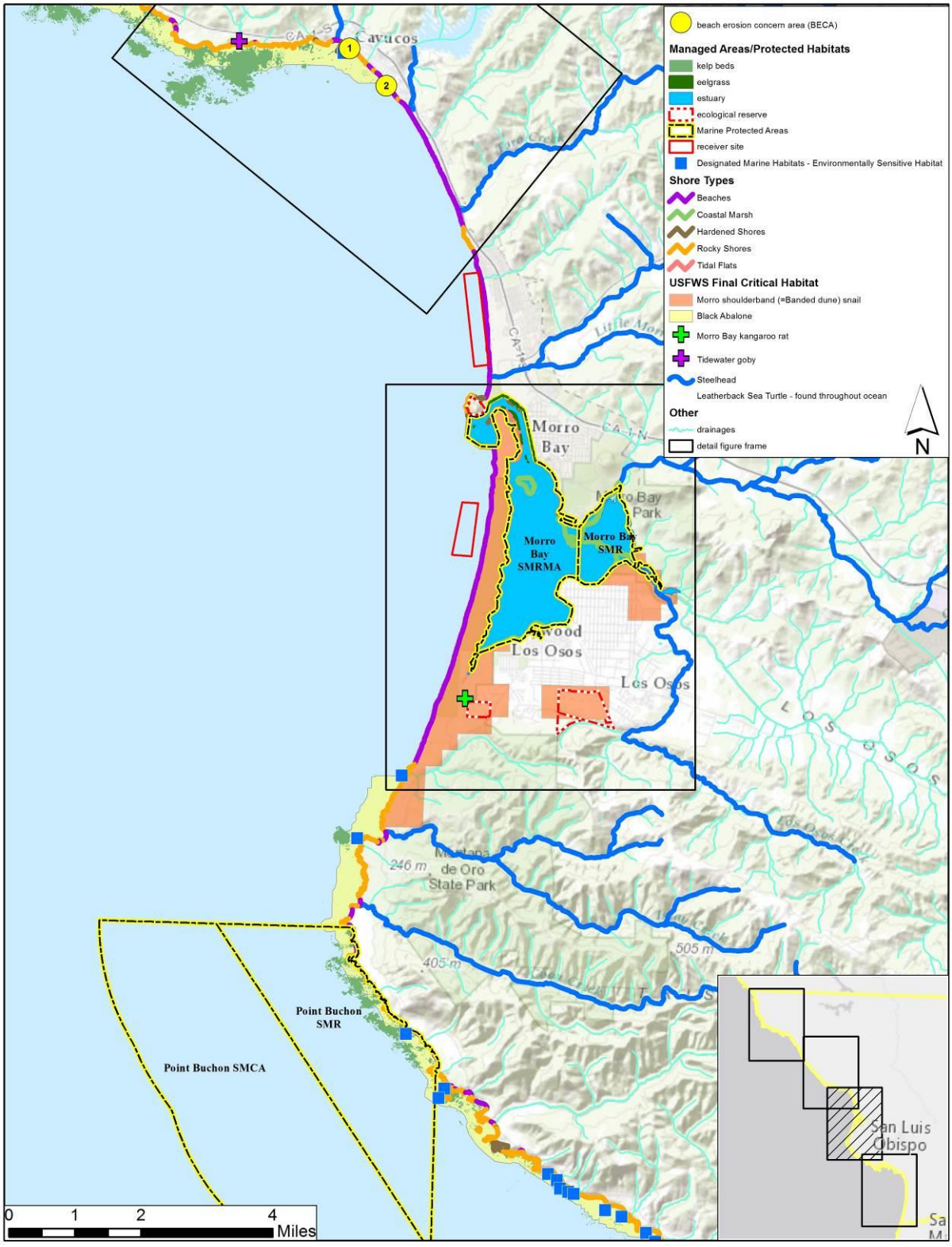


Figure ES-7. South-Central San Luis Obispo County Biological Resources.

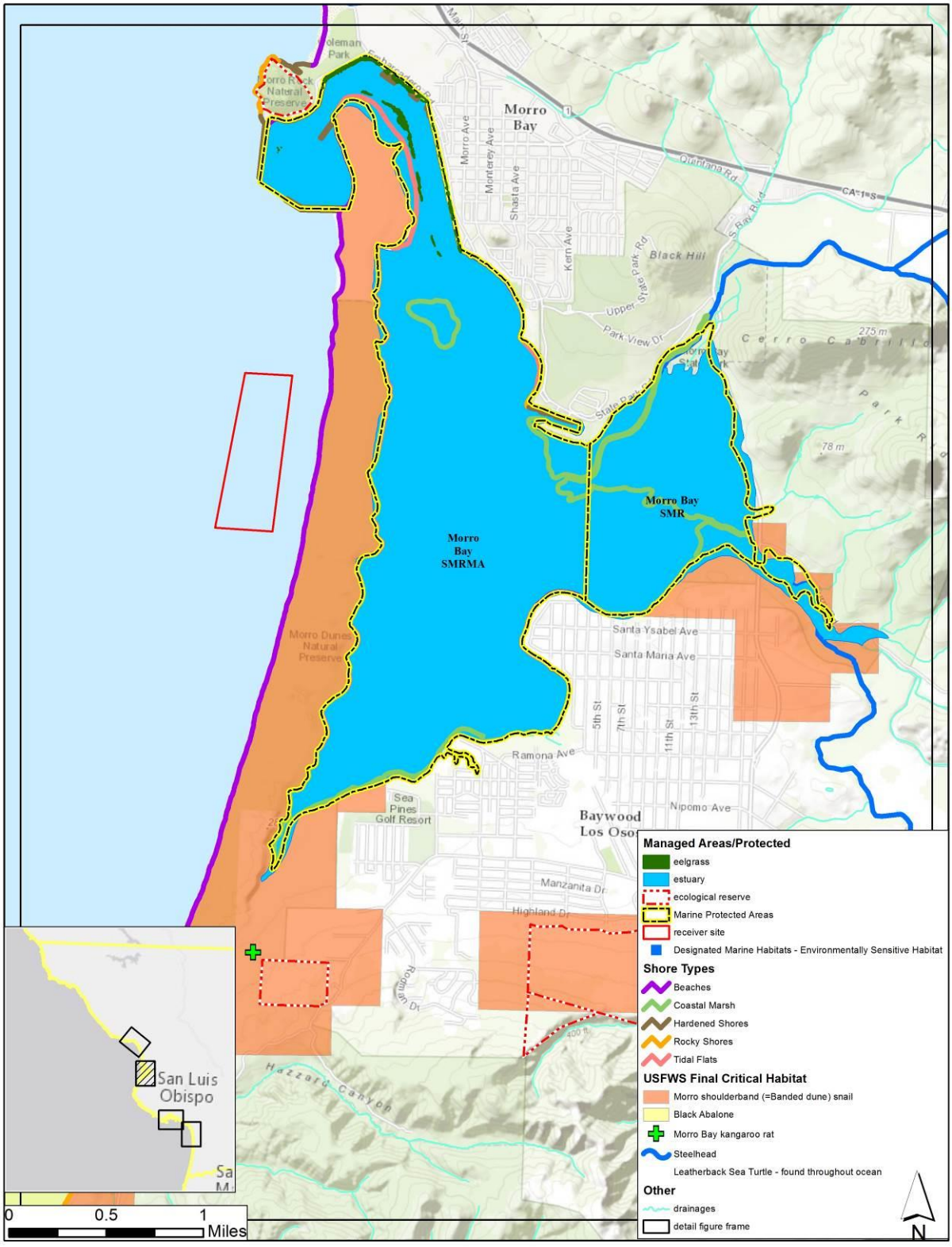


Figure ES-8. Biological Resources in Vicinity of Morro Bay.

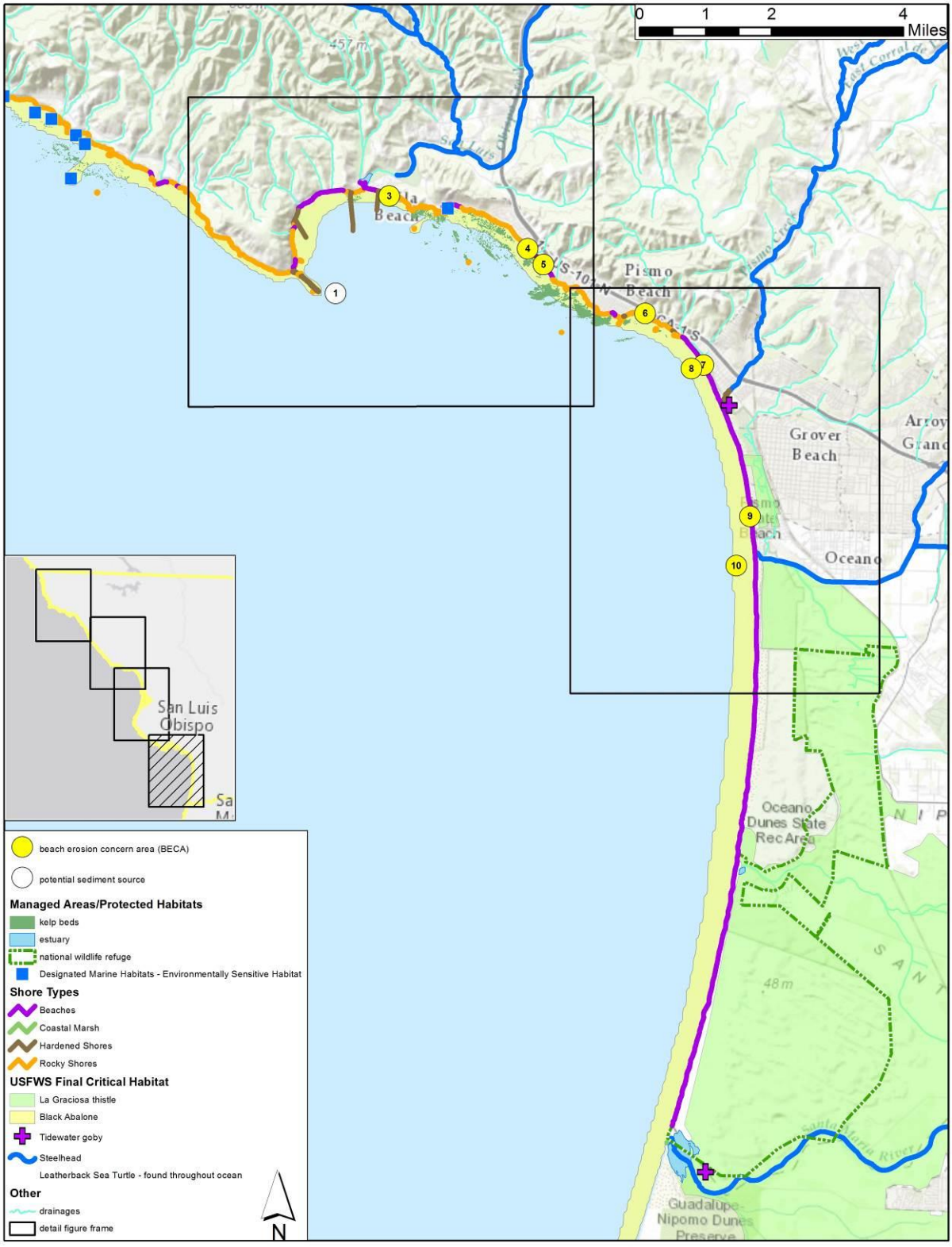


Figure ES-9. South San Luis Obispo County Biological Resources.

Several factors may contribute to the potential to affect sensitive habitats in the vicinity of RSM activities involving dredging or discharges:

- Distance between project activities and sensitive habitat (Table ES-5)
- Sand volume and duration of activity
- Oceanographic conditions (e.g., current magnitude and direction) during and after project implementation
- Physical characteristics of the hard-bottom habitat (e.g., reef heights, extent of hard-bottom area, resource development, natural sand flow dynamics through the hard-bottom area)
- Occurrence of barriers (e.g., groin, jetty) that may contribute to sand accumulation

Table ES-5. Biological Considerations and Constraints for San Luis Obispo County BECAs.

LOCATION	HABITAT TYPE	CONSTRAINTS
Cayucos State Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Steelhead Critical Habitat; Black Abalone Critical Habitat
Cayucos Bluffs Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Steelhead Critical Habitat; Black Abalone Critical Habitat
Avila Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Steelhead Critical Habitat; Black Abalone Critical Habitat
Palisades Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Black Abalone Critical Habitat
Spyglass Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Black Abalone Critical Habitat
Dinosaur Caves Beach	Sandy Beach Rocky Outcrops	Adjacent Rocky Intertidal and Kelp Forest Habitat; Black Abalone Critical Habitat
Pismo Beach	Sandy Beach	Steelhead Critical Habitat; Black Abalone Critical Habitat; Tidewater Goby Critical Habitat
Pismo Beach Nearshore	Sandy Subtidal	Steelhead Critical Habitat; Black Abalone Critical Habitat
Oceano Beach	Sandy Beach	Steelhead Critical Habitat Black Abalone Critical Habitat
Oceano Beach Nearshore	Sandy Subtidal	Steelhead Critical Habitat Black Abalone Critical Habitat

Impact Considerations

Direct, indirect, or cumulative impacts to biological habitats and resources may result from RSM activities. Direct impacts are "caused by the action and occur at the same time and place" (40 Code of Federal Regulations Sec. 1508). Examples of direct impacts include burial or removal of soft bottom or benthic invertebrates during sand placement or dredging and excavation. Direct impacts also may occur to invertebrates and fish that become entrained with water that is removed or pumped during dredging operations. There also may be the potential for direct impacts to managed species, if present in the construction area.

Generally, sandy beach invertebrate assemblages recover within one year or less, but may take longer if disturbance affects highly diverse communities, long-lived species, repetitive disturbances

occur before recovery is complete, or source materials substantially differ from existing sediment. Subtidal invertebrate recovery takes one to three years depending on water depth and environmental conditions.

Direct and most indirect impacts are associated with the construction phase of RSM activities. Impacts of potential concern during the construction phase include:

- Removal or damage to sensitive habitats or resources from equipment operation (dredges, pipelines vehicles, vessels), sand placement, or sand removal
- Disturbance or interference with movement, foraging, and/or reproduction of sensitive species from equipment operation (noise, disturbance)
- Persistent water-quality changes (e.g., turbidity) that interfere with foraging, respiration, recruitment, or reproduction of sensitive species or degrade vegetated habitats
- Potential for the release of contaminants and associated adverse effects on aquatic animals (NRC 1985, 1995)

The primary indirect impact concern of sand migration from the receiver site is the potential to degrade sensitive habitats, if nearby. Impacts of potential concern after construction include:

- Alteration of sediment, hydrodynamics, or habitat quality that delays invertebrate recovery rates
- Turbidity, sedimentation. or sand migration that degrades nearshore reefs or vegetated habitats of particular concern (HAPCs)
- Sand migration that increases the frequency or volume of maintenance dredging or excavation in nearby bays, creeks, or harbors

ES 6. Regulatory and Policy Considerations

Implementing any of the RSM measures outlined in this Plan requires following a regulatory compliance process. Although the precise requirements and process depends on the specifics of each project, regulatory compliance can generally be broken down into two major components or processes: 1) Environmental Review and 2) Permitting. The BRRG (EIC, 2006) should be referred to for more specific guidance on the requirements and necessary steps in carrying out the environmental review and permitting processes for beach-restoration projects.

Environmental review consists primarily of compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), but also with several other state and federal laws. Environmental review is typically completed or nearly completed prior to embarking on the permitting process, because the information developed during this phase will be used by permitting agencies in reviewing the project and making permit decisions (Table ES-5).

Table ES-5. Relevant regulations affecting beach restoration projects

POLICY/REGULATION	REQUIREMENT	PERMITTING AGENCY#
	FEDERAL	
NEPA	Compliance	Lead NEPA Agency
Coastal Zone Management	Coastal Consistency Determination	CCC

Act		
Rivers and Harbors Act	Section 10 Permit	USACE
Clean Air Act	Title V Operating Permit	CARB
Clean Water Act	Section 401 Certification or Waiver (401 Permit)	RWQCBs+
CWA	Section 402 NPDES Permit (NPDES Permit)	RWQCBs+
CWA	Section 404 Permit (404 Permit)	USACE
Endangered Species Act*	Section 7 Consultation	USFWS or NMFS
National Historic Preservation Act *	Section 106 Approval	State Historic Preservation Officer
Fish and Wildlife Coordination Act *	Coordination Act Report	USACE
Magnuson-Stevens Fishery Conservation and Management Act*	Assessment of Impacts to Essential Fish Habitat	NMFS
Outer Continental Shelf Lands Act	Lease Agreement for Utilization of Outer Continental Shelf Sand	BOEM
	STATE	
CEQA	Compliance	Lead CEQA Agency
California Coastal Act	Coastal Development Permit	CCC
Porter-Cologne Water Quality Control Act	Compliance Permits under CWA Sections 401, 402, and 404	SWRCB
California State Lands Public Resources Code	Lease Agreement for Utilization of Sovereign Lands	CSLC
California Public Resources Code Section 1600	Streambed Alteration Agreement (SAA)	CDFW
California Endangered Species Act	Section 2081(b) Incidental Take Permit (State) Section 2081.1 Consistency Determination (State and Federal)	CDFW
Water Quality Control Plans; California Ocean Plan	Consistency Compliance	RWQCBs +
Clean Air Act	Title V Operating Permit	Air Pollution Control Districts; Air Quality Management Districts

See List of Terms for Acronyms

* Review and compliance is usually triggered through the initial CWA Section 404 permitting process by USACE.

+ The State Regional Water Resources Control Board (SWRCB) has lead responsibility when a project involves jurisdiction by more than one RWQCB.

Federal agencies involved in conducting, reviewing, approving, or permitting potential RSM projects identified in this Plan include USACE, the USEPA, MBNMS, USGS, and BOEM. The USEPA and USACE are the two main federal agencies involved in regulating discharges of fill and dredged material; however, numerous other federal agencies are also involved in the review of proposed beach-nourishment projects and must provide approval before permits can be issued.

The CCC is the primary agency regulating activities within the coastal zone, either directly or indirectly through Coastal Consistency Determinations (federal projects) or LCP approval. Other state

agencies involved in conducting, reviewing, or approving potential RSM projects include the CSLC, CDFW, SCC, CDPR, and DBW. The agencies with primary regulatory responsibility over shoreline protective structures are the CCC and the CSLC. The SCC and DBW are both involved with funding shoreline maintenance projects and data generation, and the CDPR is involved as a land manager.

ES 7. Economic Considerations

A socioeconomic analysis of the beaches and beach recreation in San Luis Obispo County was conducted as part of Plan preparation. Because many of the beaches are small and have no official attendance records, collection of basic primary data at these sites was a paramount concern. The analysis confirms that most of the highly attended beaches are in the southern part of the County. Beach tourism, however, is an important part of the coastal economy throughout the County. Estimates of the economic impacts of Morro Bay Harbor and Port San Luis were also conducted in response to stakeholder requests.

San Luis Obispo County has a wide variety of beaches. As a general rule, the most popular beaches (e.g., Pismo and Avila) are wider sandy beaches in the southern part of the county. Northward the beaches are narrower and rockier, and the coastal communities tend to be smaller. As part of this analysis, data was collected on various amenities at each of these beaches and reaches (Table ES-6). Certain amenities were based on judgments from extensive visitation. For example, surfing was rated subjectively on a scale of 0–4 with 0 indicating little or no surfing, 1 indicating a small amount of surfing, 2 indicating moderate surfing, 3 indicating a significant surf spot, and 4 indicating a major surfing spot that surfers consider a destination site. No surfing spot in San Luis Obispo County was rated a 4. Similarly parking was rated 1–4, with a “1” indicating that parking is easy during all but the busiest times (e.g., July 4th), “2” indicating parking is only an issue on busy summer weekends or during special events, “3” indicating that parking may be difficult to find during busy times, and “4” indicating chronic parking issues. No major beaches was rated a 4; only small beaches with limited parking or access (e.g., Harmony Headlands State Park) were designated as a 4. Overall the average was 1.6 indicating that generally there is adequate parking at beaches, except during very busy times.

Table ES-6. Amenities at Beaches in San Luis Obispo County

Sandy Beaches	Trail	Bike Trail	Camp-ground	Show-er	Boating Facilities	Wildlife Viewing	Fishing	Dog Friendly	Play-ground	Visitor Center	Facilities for Disabled	Food or Drink	Rest-rooms	Fee	Parking 1-Good-4-Bad	Life-guard	Surfing 4-good, 0-nonexistent	Access 1-good -4-bad
Ragged Point Trail and Overlook	x				x		x	x				x	x		1		0	4
San Carpoforo Creek Beach	x														1		2	2
Arroyo de Coral						x									4		0	4
Piedras Blancas	x					x							x		1		0	3
Oak Knoll Creek Beach/ Arroyo Laguna	x														1		0	1
San Simeon Beach											x		x		1	x	1	1
Little Pico Creek															1		2	2
Pico Creek															1		2	1
Hearst San Simeon State Park	x		x			x					x		x	x	1		1	1
Leffingwell Landing	x				x	x					x		x		1		1	1
Moonstone Boardwalk	x							x			x				1		1	1
Fiscalini Ranch Preserve	x	x						x			x				1		0	1
Sherwood Drive Access/Harvey Beach															1		0	1
Harmony Bluffs (aka Nikki Beach)															4		0	4
China Harbor (unaccessible)															4			4
Estero Bluffs State Park	x														1		2	3
Cayucos State Beach				x			x		x		x	x	x		2		2	1
Cayucos Beach								x					x		1		2	1
Morro Strand State Beach (North)/Toro Creek													x		1		2	1
Morro Strand State Beach (South)	x										x		x		1		2	1
Morro Rock City Beach							x	x			x		x		1	x	3	1
Montana de Oro State Park	x	x	x			x	x	x		x	x		x		1		2	2
Olde Port Beach/Fishermans					x			x			x		x		1	x	0	1
Avila Beach	x	x		x	x		x		x		x	x	x		3	x	1	1
Pirates Cove (aka Cave Landing)	x														2		2	3
South Palisades City Park	x					x		x							1		1	1
Spyglass City Park								x	x				x		1		1	2
Shell Beach--Ocean Eldwayen City Park						x		x							1		1	1
Shell Beach--Margo Dodd City Park	x					x		x							1		1	1
Shell Beach--Stairway at Shelter Cove Lodge	x										x		x		3		1	3
Pismo Beach	x	x		x				x	x		x	x	x		2	x	3	1
Oceano Dunes State Vehicular Recreation Area			x				x	x			x			x	2	x	2	1
Oso Flaco (aka Guadalupe-Nipomo Dunes)	x					x					x			x	1		0	4

As is the case for 80 percent of the California coastline (Griggs, 1998), parts of the shoreline in San Luis Obispo County are actively eroding. Sea level rise is likely to exacerbate this erosion. According to Heberger, et. al., (2009), coastal erosion in the county will have a negative impact on coastal businesses and households, although the magnitude of the damages is smaller than in many areas. Heberger (2009) estimates that 1,300 residents will potentially be affected with a 1.4-m SLR by 2100 (out of an estimated total of 210,000 for the entire state).

ES 8. Recommended Regional Sediment Management Strategies

This Plan is not intended to prescribe a specific RSM measure at a given coastal erosion site, but rather present several potentially viable measures (or strategies) that could be considered for future implementation. Suggested Plan strategies presented below (Table ES-7) are based primarily on issues discussed in previous sections. Those strategies were developed using input from the Plan sponsors and stakeholders. Three types of modifiers are utilized to categorize the potential strategies:

- *Type* is separated into the following:
  - Performance activities are designed to improve performance of the CRSMP. This includes monitoring and feedback activities which could inform other CRSMP activities for better decision making. These are typically research, investigations, and studies.
  - Construction activities are projects that can be built and support coastal regional sediment management.
- *State* separates those activities that are existing and are expected to continue into the future from those that have the potential to begin (i.e., have not yet begun).

- *Duration* separates activities into those that are projects that can be completed, those that would be ongoing without end, and those that would be recurring without end.

Table ES-7. Summary of CRSMP Activities

Activity	Type	State	Duration
Support realignment of State Route 1 at Piedras Blancas	Construction	Existing	Project
Investigate nourishment at Cayucos	Construction	Potential	Project
Continue dredging & placement in Morro Bay	Construction	Existing	Recurring
Investigate landward migration of Morro Bay Sand Spit	Performance	Potential	Project
Continue dredging and placement at Port San Luis	Construction	Existing	Recurring
Implement Port San Luis sand retention methods	Construction	Potential	Recurring
Investigate Pismo Beach nourishment with Port San Luis dredge material	Construction	Potential	Recurring
Support the sediment management plan for the Twitchell Reservoir	Performance	Existing	Project
Investigate sea level rise adaptation strategies and beach sustainability	Performance	Potential	Recurring
Update sediment budget for Santa Maria Littoral Cell	Performance	Potential	Project
Develop local Sand Compatibility and Opportunistic Use Program	Performance	Potential	Ongoing
Investigate methods to assess and mitigate for upstream sand taking	Performance	Potential	Project
Support coastal shoreline setbacks in San Luis Obispo County's Local Coastal Program	Performance	Existing	Ongoing
Recommend development of stream floodplain setbacks	Performance	Potential	Project

ES 9. Implementation and Governance Structure

This Plan is a guidance document that provides a framework for regional stakeholders to use in addressing issues associated with sediment imbalances along the San Luis Obispo County coast and environs. How (governance), when and whether the Plan is implemented are decisions to be made by the stakeholders potentially affected by the Plan. This section provides an overview of what CRSMP implementation entails in general, and provides examples of how other CSMW-sponsored Plans have approached governance and implementation, as well as a range of potential options that could be pursued for implementing this Plan. It also provides a preliminary list of recommended next steps for initiating the implementation process as well as potential short-term, long-term, and ongoing implementation actions.

The Plan provides guidance to regional stakeholders by recommending a diverse set of sediment management strategies and planning processes. For example, some strategies involve continuation of

existing activities, whereas others could lead to entirely new projects or planning processes that will require funding, staffing, and studies. Local jurisdictions will likely continue to plan and implement individual projects; implementation of this Plan can provide them potential benefits through a regional perspective resulting from stakeholder coordination and cross-jurisdictional collaboration.

SLOCOG will serve as the coordinated CRSMP implementation body that has appropriate jurisdictional authorities and the ability to enter into contracts, and will seek funding and staffing to facilitate stakeholder coordination and outreach, evaluate and recommend various funding opportunities, and a regional permitting program. In order to provide strategic leadership for planning and stakeholder outreach efforts, SLOCOG has established a Policy Advisory Committee which will utilize the CRSMPs Stakeholder Advisory Group for input prior to recommendation to the full SLOCOG Board. The Policy Advisory Group is to be comprised of elected officials from: the unincorporated county (two supervisors from the three coastal supervisorial districts); the coastal cities of Grover Beach, Morro Bay and Pismo Beach, one representative each); and, two members representing affected coastal special districts in the unincorporated area (Oceano Community Service District and Port San Luis Harbor District (one representative each).

Implementation of this Plan and consideration of its recommended actions are anticipated to result in a wide range of potential benefits depending upon the specific types of RSM actions being pursued and the intensity of these efforts, the availability of funding, and level of stakeholder involvement and collaboration. The CSMW developed the CRSMP program to provide local stakeholders with a means to formulate and implement strategies for RSM policy and guidance that will help in:

- Restoring, preserving, and maintaining coastal beaches and other critical areas of sediment deficit;
- Sustaining recreation and tourism, enhancing public safety and access, restoring coastal sandy habitats; and
- Identifying cost-effective solutions for restoration of areas affected by excess sediment.

The next steps related to Plan implementation include:

- Officially adopting the Plan,
- Establishing and maintaining a coordination mechanism among the participating stakeholders that clearly states roles and responsibilities and formalizes the process
- Establishing any needed administrative procedures,
- Seeking funding and entering into contracts to facilitate plan implementation, conduct studies and collaborative planning efforts, and
- Seeking funding to maintain the staff necessary to coordinate CRSMP implementation.

1. INTRODUCTION

This San Luis Obispo County Coastal Regional Sediment Management Plan (CRSMP) was developed for the California Coastal Regional Sediment Management Workgroup (CSMW) by the U.S. Army Corps of Engineers (USACE) in partnership with Everest International Consultants and the San Luis Obispo Council of Governments (SLOCOG). The CSMW is a collaborative effort of federal, state, and local agencies and non-governmental organizations committed to evaluating and addressing California's coastal sediment management needs on a regional basis. Established in 1999, the CSMW is co-chaired by the USACE South Pacific Division and the California Natural Resources Agency (CNRA). Its creation was a response to concerns raised by the state, local governments, USACE, and environmental groups about the piecemeal identification of problems and implementation of site-specific solutions that did not effectively address critical problems along the coastline.

California's beaches are extremely valuable resources that provide critical habitats for endangered species, exceptional recreational opportunities, infrastructure protection, and over $15 billion annually in tourism-generated tax revenue (CSMW, 2002). Coastal beaches, wetlands, and watersheds have been affected, however, by extensive human alteration of the natural flow of sediment to and along the coast (**Error! Reference source not found.**). atersheds no longer provide a sufficient supply of sediment to beaches, wetlands are often compromised by too much or too little sedimentation, beaches erode because of a lack of sand, and coastal bluffs often fail during intense winter storms.

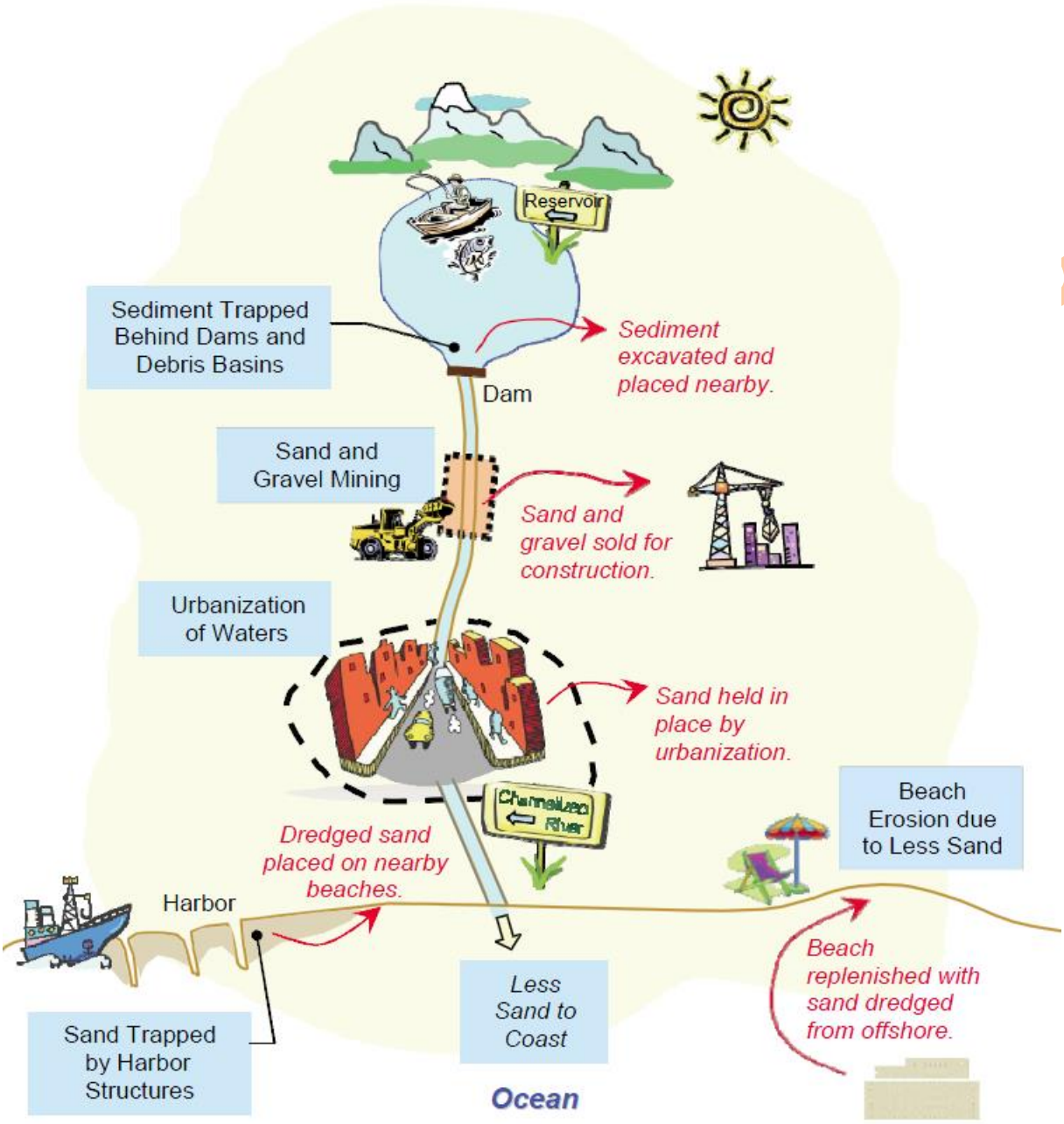


Figure 1. Existing Coastal Sediment Management Practices in Many Regions (CSMW, 2012).

Anthropogenic coastal alteration is widespread along the California coast, and a number of CRSMPs have been developed to help formulate region-specific strategies to address these issues. This Plan presents the present condition of the San Luis Obispo Coast, the future coastal impacts if no action is taken, and guidance strategies to accomplish a number of sediment-management objectives in greatly at-risk areas.

This CRSMP (Plan) strives to accomplish a number of sediment-management objectives that support CSMW's mission to conserve, restore, and protect California's coastal resources by

developing and facilitating regional approaches to managing sediment imbalances. Objectives of the San Luis Obispo County Plan include:

- restoring, preserving, and maintaining coastal beaches and other critical areas of sediment deficit
- sustaining recreation and tourism
- enhancing public safety and access
- restoring coastal sandy habitats
- identifying cost-effective solutions for the restoration of areas affected by excess sediment

1.1 ORGANIZATION

Section 2 provides the San Luis Obispo County coastal geologic, geomorphic, and ecological framework and identifies erosion areas of concern. It describes the Morro Bay and Santa Maria Littoral Cells; identifies key beaches and physical processes including coastal sediment transport, wave climate, and tidal regime; and discusses probable changes in sea-level.

Section 3 identifies sediment sources and receiver sites as well as sea-level-rise-induced flooding and erosion considerations. It discusses upland and coastal sediment sources as well as coastal erosion sites in San Simeon, Cambria, Cayucos, and Pismo Beach along the Shell Beach bluffs and the Pismo Coast Village.

Section 4 discusses Shoreline Protection Measures including setbacks, beach and nearshore nourishment, and the Sand Compatibility and Opportunistic Use Program (SCOUP). Sand stockpiling, sand retention, reefs, dewatering, and other soft solutions along with hard structures and managed retreat are also discussed.

Section 5 provides an overview of San Luis Obispo County coastal biological resources and identifies potential impacts to its coastal habitats – sandy beaches; coastal dunes and strands; coastal rivers, creeks, estuaries and wetlands; inlet embayments; littoral and sublittoral habitats; intertidal zones; rocky subtidal areas; and kelp forest, eelgrass and surfgrass. It identifies state and federally managed areas and provides a list of conservation areas, refuges, and reserves, and state parks and beaches within the county. It also lists the laws and regulations governing special status species.

Section 6 gives an overview of the regulatory compliance process for coastal RSM projects. It discusses the environmental review process and identifies agencies and local jurisdictions involved in review and permitting. It lists relevant laws and regulations administered by federal and state agencies involved in permitting and review.

Section 7 catalogs and categorizes beaches in the County based on surveys of amenities and estimates of attendance and the economic impact of beach spending in San Luis Obispo County. It reports that the Oceano Dunes Recreation area, Pismo Beach, and Avila Beach account for

more than half of all beach recreation in the County. It discusses the indirect and induced effects generated by beach spending and provides an economic impact analysis of Port San Luis and Morro Bay Harbor.

Section 8 identifies a series of potential response strategies to coastal erosion based primarily on engineering issues discussed in the Plan. Those responses were developed using input from the Plan sponsors and stakeholders. It identifies three types of activity modifiers – Type, State, and Duration. Type is separated into a) Performance activities - designed to improve performance of the CRSMP including monitoring and feedback activities which could inform other CRSMP activities for better decision making – and b) Construction activities - projects that can be built and support coastal regional sediment management.

Section 9 discusses the implementation and governance structure for the San Luis Obispo County CRSMP. Governance will involve a coordinated effort among stakeholders to establish and maintain a regional sediment management program and to evaluate and carry out the Plan's recommendations. The CRSMP is governed by the SLOCOG Board. Their CRSMP Policy Advisory Committee will review recommendations sent forward by the CRSMP Stakeholder Advisory Group and/or SLOCOG staff prior to forwarding their recommendations to the SLOCOG Board for action regarding CRSMP issues. Implementation of this Plan and consideration of its recommended actions could result in a wide range of potential benefits depending upon the specific types of RSM actions being pursued and the intensity of these efforts, the availability of funding, and level of stakeholder involvement and collaboration.

Section 10 provides citations for various engineering, environmental, and economic documents and studies used in the development of this Plan.

1.2 Definitions

The following definitions have been adapted from the USACE Water and Water Resources Glossary (http://chl.erdc.usace.army.mil/glossary).

Backshore: The zone of the shore or beach lying between the foreshore and the coastline comprising the berm or berms and acted upon by waves only during severe storms, especially when combined with exceptionally high water.

Beach: That portion of land and seabed above Mean Lower Low Water (MLLW) extending upwards to a boundary marked by a physical change of material or by permanent vegetation Includes the foreshore and backshore.

Beach Profile: A transect across the beach perpendicular to the beach slope; it may include a dune face or sea wall and extends across the beach into the nearshore zone to the depth of closure.

Compatibility: The measure to which the range of grain sizes of a potential sand source lies within the range (envelope) of natural grain sizes existing at the receiver site.

Continental Shelf: The zone bordering a continent extending from the line of permanent immersion to the depth, usually about 100 m to 200 m, where there is a marked or rather steep descent toward the great depths of the ocean.

Depth of Closure: The water depth beyond which repetitive profile or topographic surveys (collected over several years) do not detect vertical sea bed changes, generally considered the seaward limit of littoral transport. The depth can be determined from repeated cross-shore profile surveys or estimated using formulas based on wave statistics. Note that this does not imply the lack of sediment motion beyond this depth.

Fine-grained Materials (or Fines): Clays and silts, passing the #200 soil grain size sieve, or less than 0.075 millimeters in diameter.

Foreshore: The beach face, the portion of the shore extending from the low-water line up to the limit of wave uprush at high tide.

Inshore (zone): In beach terminology, the zone of variable width extending from the low water line through the breaker zone (also the shoreface).

Less-than-Optimum Beach-Fill Material: Material that is not compatible in grain size with sand at the dry beach, but is compatible with material within the nearshore portion (between MLLW and the depth of closure) of the receiver site. The fines fraction should be within 10% of that contained within existing nearshore sediments that exist along a profile. Typically, the percent fines of the nearshore portion of a beach profile in California can range from 5% to 35%. Therefore, less-than-optimum beach fill material may contain between 15% and 45% fines.

Littoral Cell: A reach, or compartment, of the shoreline in which sediment transport is bounded. In theory, it has zero longshore sediment transport beyond its updrift and downdrift boundaries. It contains sediment sources (e.g., rivers, coastal bluffs), storage areas (beaches), and sinks (submarine canyons). Each cell is sedimentologically isolated from other nearby littoral cells.

Nearshore (Zone): An indefinite zone extending seaward from the shoreline well beyond the breaker zone. It is the inner part of the continental shelf.

Offshore (Zone): The zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the sea bed on wave action is small in comparison with the effect of wind. The sea bed is seaward of the depth of closure.

Opportunistic Sand: Surplus sand from various source materials, including upland construction, development projects, and flood control (e.g., dams, channels, and debris basins).

Optimum Beach Fill Material: Material compatible with the dry-beach portion of the beach profile. The fines fraction of the grain size of this material can be within 10% of that of the existing dry-beach sediments, which typically range from 0% to 5% fines. Therefore, optimum beach fill material may contain up to 15% fines.

Receiver Site: The entire related system of coastal environments that would receive opportunistic materials, including the beach, nearshore, and offshore regions.

Sand: Sediment particles, often largely composed of quartz, with a diameter of between 0.062 mm and 2 mm, generally classified as fine, medium, coarse or very coarse. Beach sand may sometimes be composed of organic sediments such as calcareous reef debris or shell fragments.

Beach Sediment: Unconsolidated *p*articles derived from rocks or biological materials that are suitable for placement at the coast to nourish the littoral zone. This material is assumed to possess a significant fraction of sand, upwards of 75%. In some instances, however, sediment having a sand fraction between 51% and 75% may also be suitable for beneficial use at the coast, depending on location.

Upland Sediment: Surplus sandy material available for beach fill from sources located inland from the mean high tide line. They can constitute dry sources away from rivers and lakes, or wet sources at rivers and lakes.

Shoreface: The narrow zone seaward from the low tide shoreline, covered by water, over which the beach sands and gravels actively oscillate with changing wave conditions (also the inshore zone).

Shoreline: The intersection of the land with the water surface. The shoreline shown on charts represents the line of contact between the land and a selected water elevation. In areas affected by tidal fluctuations, this chosen line of contact is the mean high water line.

2. SETTING

The Plan extends approximately 96 miles from the Monterey County line to the Santa Barbara County line. It comprises the watersheds, coast, and nearshore (Figure 2). The area includes a number of popular recreational beaches, two harbors (Morro Bay and Port San Luis), and a large dune field ranging from the Pismo Dunes through the Nipomo-Guadalupe Dunes. The coastline is broken into a variety of landforms – e.g., sand and cobble beaches, rocky intertidal areas, rocky bluffs, and loosely consolidated bluffs.

Figure 2: San Luis Obispo County Plan
(coastline in red, county lines dashed, and watershed boundaries in orange).

2.1 BEACHES

San Luis Obispo County includes a wide variety of beaches (Figure 3; Table 1) ranging from large, highly attended beaches (e.g., Pismo Beach and Morro Bay) to secluded and undeveloped pocket beaches visited rarely and by only the most dedicated wilderness enthusiasts. Beach names and descriptions were compiled from site visits, aerial photos for various locations and dates (Google Earth Pro; California Coastal Records Project), and the literature (DNOD, 1977; Californiabeaches.com).

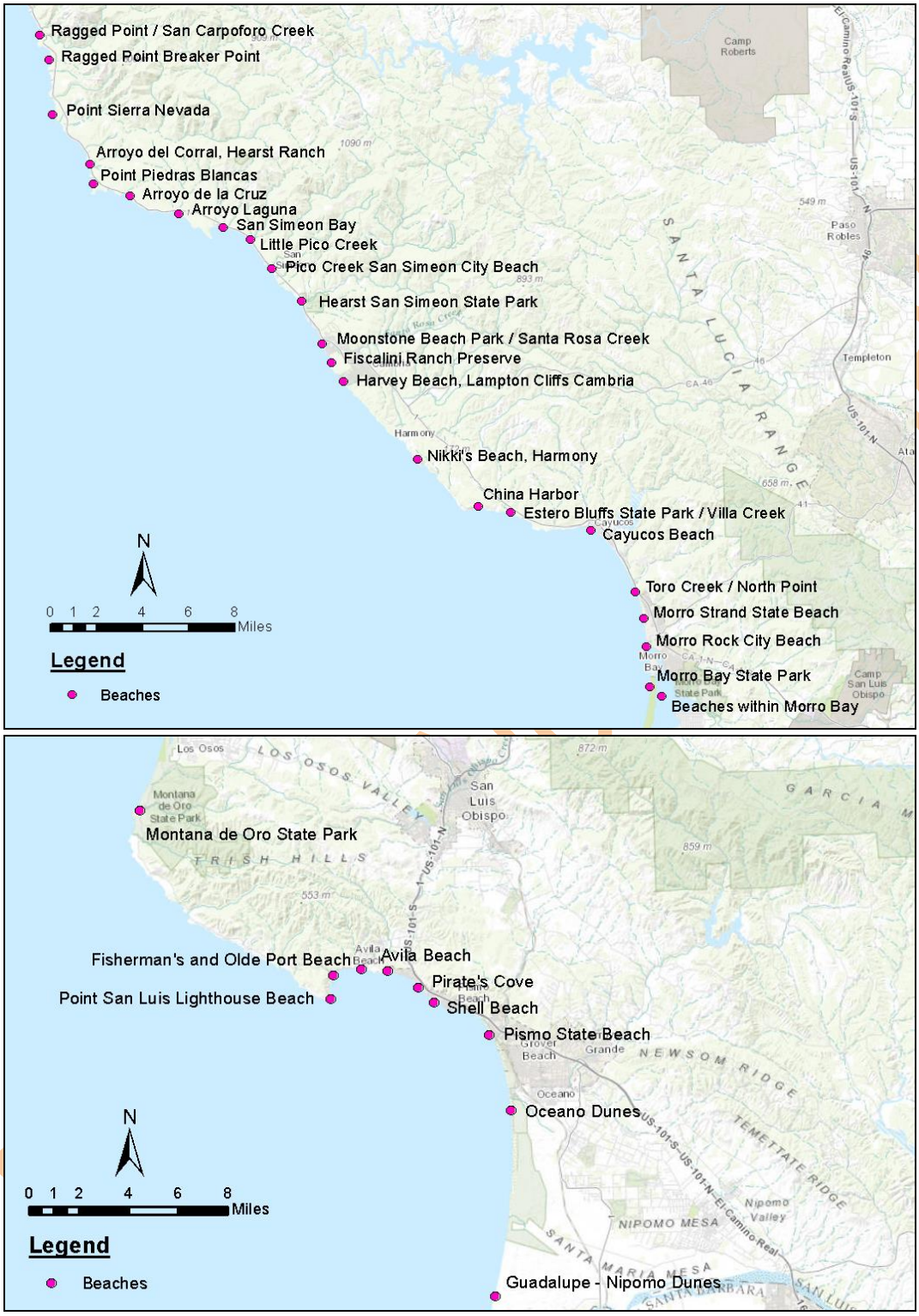


Figure 3. Beaches of San Luis Obispo County

Table 1. Beaches of San Luis Obispo County

#	BEACH NAME
1	Ragged Point – San Carpoforo Creek
2	Ragged Point – Breaker Point
3	Point Sierra Nevada
4	Arroyo de la Cruz
5	Arroyo del Corral
6	Point Piedras Blancas
7	W.R. Hearst Memorial State Beach (San Simeon Bay)
8	Little Pico Creek
9	Pico Creek
10	San Simeon Creek
11	Moonstone Beach and Leffingwell
12	Santa Rosa Creek
13	Fiscalini Ranch Preserve to Lampton Cliffs
14	Harmony Headlands State Beach (aka Nikki's Beach)
15	China Harbor
16	Estero Bluffs State Park, Villa Creek
17	Cayucos State Beach
18	Toro Creek / North Point
19	Morro Strand State Beach
20	Morro Rock City Beach
21	Beaches within Morro Bay
22	Morro Bay State Park / Morro Dunes Natural Preserve
23	Montaña de Oro State Park
24	Point San Luis to Olde Port Beaches
25	Avila Beach
26	Pirate's Cove
27	South Palisades Park
28	Shell Beach
29	Pismo State Beach
30	Oceano Dunes
31	Guadalupe-Nipomo Dunes

Summary descriptions of these beaches follow, and many are discussed in more detail in the economics section.

 # 1, Ragged Point Beach – San Carpoforo Creek: Also called San Carpoforo Beach, this wide sandy beach and bar across the creek's mouth are backed by a lagoon and low active dunes. Active dunes have moving sand and are generally without vegetation. A small sandy pocket beach is formed along a high bluff downcoast of the creek mouth.

 # 2, Ragged Point Beach – Breaker Point: Rocky point with offshore rocks and reef backed by high, wave-undercut, eroding bluffs with active sides. Long sandy pocket beach with offshore rocks backed by vegetation covered-dunes at the base of a high bluff.

 # 3, Point Sierra Nevada: Sandy beach backed by low active dunes and vegetated dunes.

 # 4, Arroyo de la Cruz Beach: Also called Arroyo de la Laguna, this location includes a sandy bar and beach backed by active dunes. La Cruz Rock is a well-known offshore landmark.

 # 5, Arroyo del Corral Beach: Includes Hearst Ranch with narrow sandy pocket beaches with active dunes between rocky points. Offshore rocks and reefs are backed by low, wave-cut rocky bluffs bisected by creeks. The beach is accessible by trail from old abandoned motel parking lot.

 # 6, Point Piedras Blancas: Rocky point with a Coast Guard station and lighthouse. Offshore rocks, reefs, sea stacks, and sea caves and small sandy pocket beaches between rock outcrops are backed by low, wave-cut, eroding bluffs. Sandy pocket beaches with active low dunes are backed by low, wave-undercut bluffs and the highway. State Route 1 along the rim of a low wave-cut bluff is endangered during high wave conditions. Further south is a sandy pocket beach with an elephant seal rookery.

 # 7, W.R. Hearst Memorial State Beach (San Simeon Bay): A sandy beach in a hooked bay, backed by a low rocky bluff, park facilities, and houses. San Simeon Bay is more or less undeveloped. The coastline within San Simeon Bay consists of a narrow sandy beach with offshore rocks and reef backed by wave cut eroding bluff.

 # 8, Little Pico Creek: Sandy beach and bar at creek mouth. Narrow sandy and rocky beaches with offshore rocks and reef backed by wave cut, eroding bluff. State Route 1 is endangered by bluff erosion in this area.

 # 9, Pico Creek: A narrow sandy beach at the creek mouth backed by a flood plain, low wave cut bluff, motels, and a highway.

 # 10, San Simeon Creek and Hearst San Simeon State Park: A narrow sandy beach and bar across the creek mouth is backed by a lagoon and park. The narrow sandy beach is backed by a low wave cut bluff. State Route 1 is endangered by bluff erosion in this area.

 # 11, Moonstone Beach and Leffingwel Cove: **N**arrow sandy pocket beaches between rocky points have offshore rocks and reefs and are backed by a low eroding bluff. Many private homes, hotels, and tourist facilities are present.

 # 12, Santa Rosa Creek: Sandy beach and bar across the creek mouth backed by flood plain and Moonstone Beach State Park. Shamel Community Park is located just south of Santa Rosa Creek and also has beach access and facilities.

 # 13, Fiscalini Ranch Preserve to Lampton Cliffs: These beaches include Fiscalini Ranch Preserve, Harvey's Beach and Lampton Cliffs County Park. A rocky shore with offshore rocks and reef consists of small cobble, and sand beaches between rocky points, backed by low, wave cut, eroding bluffs. On the north edge (Abalone Cove), houses are endangered by bluff erosion. At the south edge of the preserve, Sherwood Drive has stairway access to very small, coarse sand beaches.

 # 14, Harmony Headlands State Park (Nikki's Beach): This beach is typical of much of the surrounding coastline. There is a rocky shore with offshore rocks and reef, with occasional small cobble and sandy pocket beaches between rocky points that are backed by wave-cut eroding bluffs.

 # 15, China Harbor: Narrow sandy pocket beach with offshore rocks and reefs, backed by wave cut eroding bluffs.

 # 16, Estero Bluffs State Park and Villa Creek: Narrow sandy pocket beaches between rocky points with offshore rocks and reefs backed by wave-cut eroding bluff. The mouth of Villa Creek is backed by a marsh and creek flood plain.

 # 17, Cayucos State Beach including Whale Rock: A sandy beach at the mouth of a creek contains beach facilities and commercial buildings that are protected by timber and concrete seawalls. A small harbor is protected by a rock breakwater. Nearby narrow sandy and rocky beaches with offshore rocks and reefs are backed by low rocky bluffs. Houses and a road are endangered by bluff erosion. Some low concrete revetments are present in this area.

 # 18, Toro Creek: A narrow sandy beach with offshore rocks backed by park facilities, lagoon, and creek flood plain.

 # 19, Morro Strand State Beach: A wide sandy beach, backed by low, active, sparsely covered dunes, houses, park, high school, and sewage treatment plant. The beach is stabilized by a tombolo that has formed behind Morro Rock.

 # 20, Morro Rock City Beach: Wide sandy beach produced by the tombolo that has formed behind Morro Rock. The beach is backed by oil storage tanks, roadway, and a power plant. The oil storage tanks and power plant are no longer in operation.

 # 21, Beaches within Morro Bay: There a handful of beaches and coastal access sites within Morro Bay such as Coleman Park, Tidelands Park, Bayshore Bluffs Park, Baywood Park Beach, and Pasadena Park.

 # 22, Morro Bay State Park, Morro Dunes Natural Reserve: Also called Sand Spit Beach, this includes a sandy beach backed by active dunes, high intermediate and old dunes with vegetative cover, and frequent blowouts traversing dune field to shore of bay. El Moro Elfin

Forest and Embarcadero Road also offer coastal access, but these locations are generally rocky shores.

*# 23, Montaña de Oro State Park***.** Includes Hazards Canyon, Spooner's Cove/Islay Creek, Coon Creek Beach, and Point Buchon to Diablo Canyon. Access to Point Buchon is through an easement provided by PG&E, as this area is beyond the southern border of the state park. A rocky shore, containing narrow sandy pocket beaches formed between rocky points with sea stacks, offshore rocks, and flat rock reefs is backed by wave-undercut eroding bluffs of a wide coastal terrace. The rocky shore has been eroded into long thin protrusions, containing sea caves and arches.

 # 24, Point San Luis to Olde Port Beach: This section of coastline also includes Lighthouse Beach and Fisherman's Beach. This stretch is characterized as a rocky shoreline, with offshore rocks and sea stacks backed by steep hills. Small sandy pocket beaches have formed at the base of the breakwater and around the pier. Nearby narrow sandy pocket beaches with flat offshore rock reefs are backed by Avila Beach Drive, which has been benched into a steep hillside. Olde Port Beach includes recreational facilities such as restrooms and an unpaved boat launch access point.

 # 25, Avila Beach: A narrow sandy pocket beach with a pier, backed by beach facilities, concrete and rock seawall, road, and commercial buildings.

 # 26, Pirate's Cove: A narrow sandy pocket beach, backed by a high, wave-cut and eroding bluff belonging to a narrow coastal terrace. Rock slides are present along base, face, and rim of the bluff.

 # 27, South Palisades Park: Includes Ebb Tide Park. Narrow sandy pocket beaches with flat, offshore reefs are backed by a highway that has been benched into a steep hill. Stairway access points at the Cliffs Resort, Shelter Cove Lodge, and Shore Cliff Lodge provide access to a sandy beach, although the beach can be narrow to non-existent at high tides.

 # 28, Shell Beach: This stretch of coastline includes Spyglass Park, Memory Park, Seacliff Park, Eldwayen Ocean Park, Margo Dodd Park, Dinosaur Caves Park, and Elmer Ross Beach. **A r**ocky shore, containing cobble and sand beaches with flat offshore rock reef, rocks, and sea stacks, is backed by wave-cut eroding bluffs. Parks, roads, and houses are present along the rim of a wide coastal terrace. Parks and homes are endangered by bluff erosion in this area. The bluff is partially protected by a concrete seawall and concrete bag revetment.

 # 29, Pismo State Beach: Includes Grover Beach. A wide sandy beach backed by active dunes, houses, intermediate, and old dunes with dense vegetative cover, marsh, lake, and highway. Timber ramps providing beach access are subject to damage during high wave conditions. The dune faces are wave-eroded with frequent active sand slides. At Arroyo Grande

Creek, the sand bar and low active dunes across the creek mouth are backed by a lagoon, marsh, and flood control channel.

 # 30, Oceano Dunes: This stretch of coastline includes Oceano Dunes State Vehicular Recreation Area, Oceano Dunes Natural Preserve, and Oso Flaco Lake. A narrow sandy beach backed by active dunes with sparse vegetative cover, high intermediate and old dunes with vegetative cover, and marshes as well as occasional oil wells. Dune faces are wave-eroded with frequent active sand slides. Oso Flaco Lake includes a boardwalk and wheelchair access to the beach.

 # 31, Guadalupe–Nipomo Dunes: This area includes the Guadalupe Nipomo Dunes National Wildlife Refuge and the Rancho Guadalupe Dunes Preserve. A sand bar across the Santa Maria River's mouth is backed by active low dunes, a lagoon, marsh, park, now-defunct oil wells, and a road within the floodplain. Park facilities are subject to damage during high river flow conditions.

The next beaches to the south are Mussel Point and Point Sal State Park, both of which are sometimes mentioned in the context of the geology and coastline of San Luis Obispo County. However, these beaches are within Santa Barbara County; they are outside of the Plan's boundary and therefore not considered further.

2.2 Coastal Sediment Transport

This stretch of coastline can be divided by many possible features, of which the physical process of sand transport seems most appropriate for a CRSMP. These physical processes are most easily described by a sand accounting system called the sediment budget and a geographical grouping method based on the concept of a littoral cell. The sediment budget approach was developed to understand the impact of coastal processes on shoreline change. The sediment budget conceptually accounts for inflows (sources), outflows (sinks), and storage of sediment within a littoral cell. A littoral cell is a coastal compartment or physiographic unit that contains sediment sources, transport paths, and sediment sinks Patsch and Griggs, 2007) A littoral cell is typically a portion of the coastline that does not significantly transport to or receive littoral sediment from another cell in either the upcoast or downcoast direction. Most cells, however, are not absolutely separated and do have some sediment leakage between them.

There are two littoral cells along the coast of San Luis Obispo County – the Morro Bay Littoral Cell in the north ([Patsch and Griggs, 2007]; also called the Estero Bay Littoral Cell [Dingler et. al., 1982]) and the Santa Maria Littoral Cell (DNOD, 1977; SIO, 2004). Some researchers consider the Santa Maria Littoral Cell to be a sub-cell within the Santa Barbara Littoral Cell (Patsch and Griggs, 2007). However, within the context of the San Luis Obispo County CRSMP, reference will only be made of the Santa Maria Littoral Cell, and the northern

boundary has been interpreted to follow SIO (2004). These littoral cells are shown graphically in Figure 4, with arrows showing predominant directions of sediment transport.

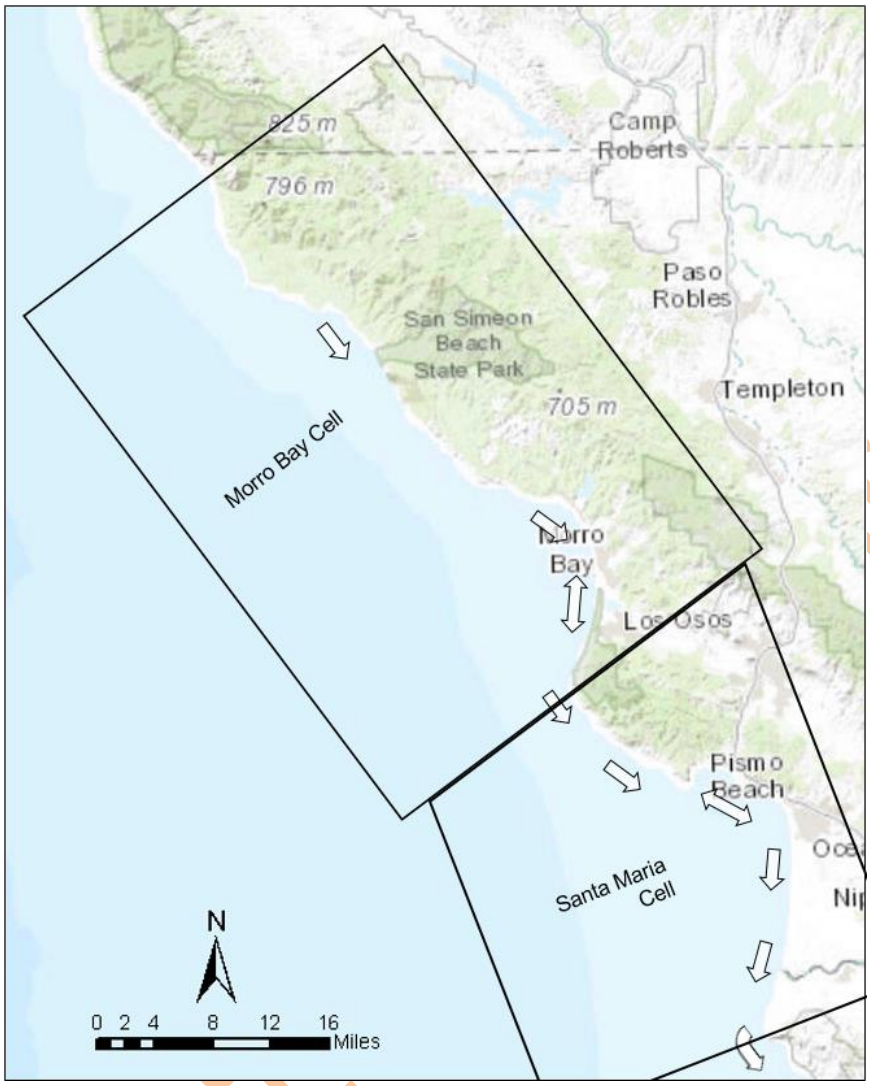


Figure 4. Morro Bay and Santa Maria Littoral Cells

Within the littoral cell a complete cycle of sedimentation exists that can include erosion of upland terrain, fluvial transport to the shoreline, littoral transport along the shoreline with storage within the cell, and transport out of the cell. Sediment sources to a cell include rivers, bluffs, dunes, and artificial nourishment. Once sediment is entrained in the littoral transport system it can be lost from that system through various sinks, including aeolian losses to dunes, cross-shore transport to offshore, or by channeling of the sediment onto the continental shelf via a submarine canyon. Some sinks, such as dunes, can later become sand sources with sand migrating back to the beach when sea level rises. Sand moves through a littoral cell along the beach and/or nearshore zone from source to sink and is temporarily stored at beaches within the cell. The sediment budget is either in balance with stable beaches, in a surplus with accreting beaches, or in deficit with eroding beaches. The longshore sediment transport rate is an indicator of the

volume of sand moving through a littoral cell over time. Sediment budgets and longshore sediment transport are tied to each other primarily via wave action in the surf and swash zones near the shoreline.

2.2.1 Morro Bay Littoral Cell

As with the rest of the San Luis Obispo coast, net sediment transport occurs in a southerly direction (southeast along the coastline), with significant temporary reversals depending on changes in the wave climate, which are typically associated with seasonal weather patterns. Morro Bay constitutes a notable discontinuity in the sediment transport, as the bay entrance intercepts approximately 115,000 cubic yards per year (yd^3/yr) of sediment.

Key quantitative sediment components of this littoral cell available in the literature include the following:

- Dredging and sediment bypassing in the vicinity of, and from the entrance of, Morro Bay has occurred from the 1940s to the present day. Documented totals for this period are almost 8.2 million cubic yards (yd^3) (USACE, 2015b, 2015c).
- Measured sedimentation rates in the bay entrance averaged 115,000 cubic yards per year (yd^3/yr) from 1944-1987 (USACE, 1991).
- Aeolian transport and sediment from local streams contributes to sedimentation inside Morro Bay. Aeolian transport from the barrier beach to Morro Bay is estimated at 8,300 yd^3/yr (USACE, 2003). Others estimated a landward migration of the barrier beach of 1.1 to 1.7 ft/yr into the bay (USACE, 2003).
- Hapke et al. (2006) analyzed 447 consistent beach profile transects within the Morro Bay Littoral Cell. This analysis began from map sheets from the 1800s, incorporating archive aerial photos and LiDAR surveys in recent years. On the average throughout the cell, the sandy beach has narrowed only 4 inches per year, with short term, episodic events, averaging 2 feet per year over the littoral cell.
- The gross longshore sediment transport rate near Morro Bay was estimated to be between 2 to 3 million yd^3/yr, and the bay entrance captures only a fraction of this (USACE, 1991). The Estero Bay coast (Morro Strand Beach) is dominated by southerly net longshore sediment transport of 71,000 yd^3/yr. Near the bay entrance and south (Morro Bay State Park) the transport is dominated by northerly net longshore sediment transport of 400,000 yd^3/yr (USACE, 1991).
- Griggs et al. (2005) estimated that north of Morro Rock, there is a net southward drift of 18,000 yd^3/yr and south of Morro Rock there is a net northward drift of 32,000 yd^3/yr. It is assumed that these more recent values are more accurate than the 1991 values given that more data and updated methods were available for this recent estimate.
- Human intervention into natural processes has resulted in the sandy beaches around Morro Bay being wider than they might naturally be, providing protection for coastal development (Griggs et al, 2005).

2.2.2 Santa Maria Littoral Cell

The Santa Maria Littoral Cell extends either from Point Buchon (SIO, 2004) or from Point San Luis (DNOD, 1977), terminating in the south at Point Sal. This Plan utilizes the boundary discussed by Scripps, to incorporate areas such as Port San Luis that would otherwise be left out of the littoral cell. Quantitative sand components for this littoral cell are from Bowen and Inman (1966), except where stated otherwise:

- Gross longshore sediment transport was estimated at 214,000 yd^3/yr to the north and 276,000 yd^3/yr to the south. This represents conditions after constructions of dams on Santa Maria and Santa Ynez Rivers, roughly between 1957 to 1960..
- This leaves a relatively small net longshore sediment transport rate of approximately 62,000 yd^3/yr to the south.
- The Santa Maria River is the largest sand contributor within this littoral cell, contributing an average of approximately 60,000 yd^3/yr.
- Approximately 125,000 yd^3/yr of sand is lost to the Oceano Dunes and Guadalupe-Nipomo Dunes (Pismo Beach to Santa Maria River) through aeolian transport.
- Approximately 63,000 yd^3/yr of net sand transport leaves south past the Santa Maria River.
- San Luis Obispo Creek contributes 8,000 yd^3/yr and Arroyo Grande Creek contributes 13,000 yd^3/yr of sand to the littoral cell.
- Sediment contribution from bluff erosion is negligible.
- Only a small portion of the 2,000 to 6,000 yd^3/yr contributed to the littoral system by the Irish Hills (upcoast of Port San Luis) area is deposited east and northeast of the end of the Port San Luis breakwater (Everts Coastal, 2000).

Everts Coastal (2000) hypothesized a three-mile long sub-cell called the San Luis Obispo Bay Littoral Cell extending from Point San Luis in the west to Fossil Point headland east of Avila Beach. For the purposes of the current report, this sub-cell will be considered part of the larger Santa Maria Littoral Cell. Net longshore sediment transport past Nobi Point (also known as Tunnel Point) was estimated at approximately 2,800 yd^3/yr to the west. Gross longshore sediment transport at Avila was estimated at approximately 20,000 yd^3/yr. Additional details for this sub-cell are available from Everts Coastal (2000).

2.3 Physical Processes

Several physical processes – wave climate, tidal regime, and changes in sea-level – work in concert to shape the diverse shoreline environments along the San Luis Obispo County coast.

2.3.1 Wave Climate

The wave climate changes daily, weekly, monthly, and seasonally, which results in complex changes at the coast. Waves of varying periods, size, and approach direction affect different parts of the San Luis Obispo County littoral cells depending on coastline orientation. Most wave

energy approaches from the northwest and west, often in the form of swell generated by extratropical cyclones and cold fronts in the North Pacific (Storlazzi and Wingfield, 2005). This swell, which tends to peak in size and period during the winter months, is responsible for the largest waves (Storlazzi and Wingfield, 2005). Additional wave energy from the northwest approaches the coast in the form of wind waves, which occur most frequently between April and October when the California high-pressure system generates northwesterly winds (Storlazzi and Wingfield, 2005).

Waves also approach from the south and southwest, although this occurs with less frequency and intensity than the North Pacific swell (Storlazzi and Wingfield, 2005). In the summer months, strong storms in the southern hemisphere generates swell that can reach most of the coast. Winter storms may also generate local wind waves, which can propagate in a wide range of directions depending on the storm's track. When taken together, the predominant wave energy approaches the cell from the northwest, and the scientific consensus is that the net direction of sediment transport is from the northwest to the southeast (Patsch and Griggs, 2007).

Wave climate also fluctuates over inter-annual and longer time periods in concert with ocean-atmosphere oscillations such as the El Niño Southern Oscillation (El Niño). Predominately, the West-Coast scientific community believes that unusually strong storms and large damaging waves are associated with moderate to strong El Niño conditions in the Pacific (Seymour, 1998; Storlazzi and Griggs, 2000; Griggs et al. 2005). These storms tend to follow a more southerly track when El Niño conditions are strongest, resulting in more direct impacts from storms along the California coast. El Niño conditions generally occur every 3 to 7 years, although the particularly intense and damaging El Niños (e.g., 1982–1983, 1997–1998) tend to occur on the scale of every 10 to 20 years (Storlazzi and Griggs, 2000). Recent research also suggests that the frequency of strong El Niños could double under current global warming projections (Santoso et al. 2013).

There is also evidence that a longer-term (20 to 30 year) climatic oscillation in the North Pacific influences storm activity along the California Coast (Bromirski et. al, 2003). This periodic change is now commonly referred to as the Pacific Decadal Oscillation (PDO), with phases of anomalously warm ocean conditions alternating with cooler conditions (Mantua and Hare, 2002). Similar to El Niño conditions, PDO warm phases have been associated with periods of increased storm frequency and intensity, resulting in accelerated erosion rates (Orme et al. 2011; Russell and Griggs, 2012). Several studies have linked the oscillations of the PDO to changes in beach width, with beach narrowing (i.e., erosion) occurring during warm phases and widening (i.e., accretion) during cool phases (Revell and Griggs, 2006; Zoulas and Orme., 2007). These studies occurred in southern California, however, which has a somewhat different wave climate because of a more east-west orientation and the presence of the Channel Islands. Even with these regional differences, the alternating phases of the PDO still exert considerable influence over the wave climate along much of the California coast.

2.3.2 Tidal Regime

The regional tidal regime is mixed semidiurnal, with two high tides and two low tides each day. The two high tides and two low tides that occur each day are of unequal height, and this difference varies with longer-term tidal cycles. The primary tidal station is at Port San Luis (Table 2), which has a diurnal tidal range (MHHW minus MLLW) of 5.3 feet (NOAA, 2012a). The chance of inundation of beaches and damage to coastal infrastructure markedly increases when high tides coincide with peak wave energy and surge during storms.

Table 2: Tidal datums for Port San Luis relative to MLLW.

Tidal Datum (NOAA station 9412110)	Value (ft)
Mean higher-high water (MHHW)	5.33
Mean high water (MHW)	4.62
Mean tide level (MTL)	2.83
Mean sea level (MSL)	2.80
Mean low water (MLW)	1.04
NAVD 88	0.08
Mean lower-low water (MLLW)	0
Highest observed water level (18 January 1973)	7.65

2.3.3 Changes in Sea-Level

The average global sea-level has been rising since measurement began in the mid-nineteenth century. This rise increases the vulnerability of coastal infrastructure to coastal erosion (Russell and Griggs, 2012). This trend has been documented at the Port San Luis tidal station – 0.029 in/yr for the 69-year period of 1945 to 2014 (totaling about 2 inches). Data from the San Francisco station, which covers 1906 to 2004, shows that relative sea-level has risen at an average rate of 0.084 in/yr (totaling a little more than 8 inches over 98 years). Sea levels tend to widely fluctuate around the mean with spikes correlating with El Niño seasons (PWA et al., 2008). In addition, recent research suggests that sea level rise on the West Coast has been suppressed by wind stress patterns associated with the warm phase of the PDO, and may accelerate in response to a recently observed change in wind stress patterns (Bromirski et al., 2011).

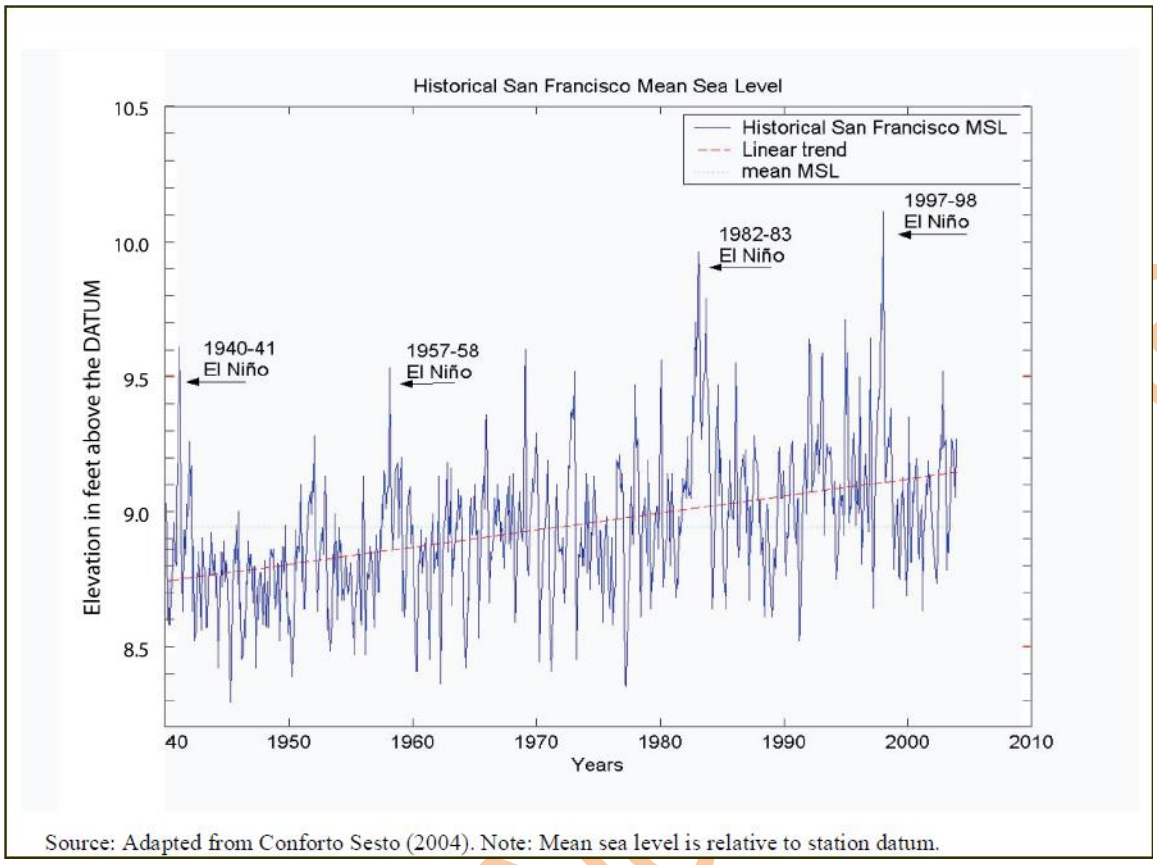


Figure 5. Monthly averaged sea level at San Francisco. Source

Although there is strong consensus that sea-level is expected to rise in the future, there is still considerable uncertainty regarding the magnitude of this rise, with differences of over several feet between high and low scenarios predicted by the National Research Council (NRC; [Figure 6]). As a result, the federal government, specifically USACE, is incorporating this uncertainty in into its missions by evaluating how a number of sea level scenarios would affect future coastal projects (USACE, 2013). In addition, the NRC completed a region-specific assessment of sea level rise data for the U.S. West Coast, which includes a comprehensive overview of region-specific factors (climate, tectonics) that influence sea-level change along the California coast (NRC, 2012).

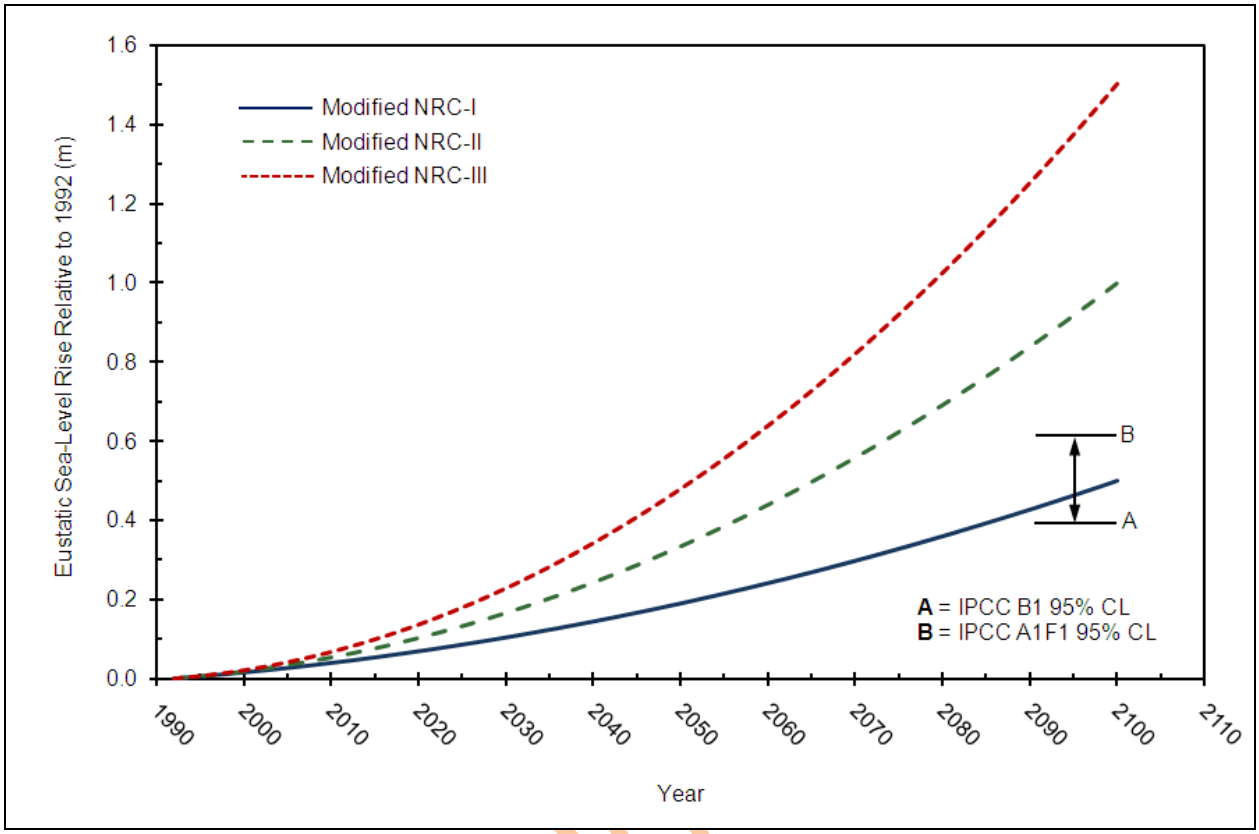


Figure 6. Modified NRC (1987) global mean sea level rise scenarios and the Intergovernmental Panel on Climate Change (2007) scenario. Source: USACE (2011).

Local and state governments are also involved in planning for future sea level rise, with municipalities (e.g., City of Santa Cruz, 2011) and state agencies (CCC, 2015) studying the potential impacts of sea level rise on coastal infrastructure. In 2009, a report funded by the California Ocean Protection Council presented maps of future coastal erosion hazard areas based on high (55") and low (39") sea level rise scenarios by the year 2100 (PWA, 2009). The report was covered much of northern and central California, including the 77 miles of San Luis Obispo County (Table 3; Table 4).

Table 3. Erosion area with a 1.4 m sea level rise, by county.

County	Dune erosion miles^2 (km^2)	Cliff erosion miles^2 (km^2)	Total erosion miles^2 (km^2)
Del Norte	1.9 (4.9)	2.6 (6.7)	4.5 (11.7)
Humboldt	3.7 (9.6)	2.4 (6.2)	6.1 (15.8)
Mendocino	0.7 (1.9)	7.5 (19.4)	8.3 (21.5)
Sonoma	0.6 (1.6)	1.6 (4.1)	2.2 (5.7)
Marin	1.0 (2.6)	3.7 (9.6)	4.7 (12.2)
San Francisco	0.2 (0.6)	0.3 (0.8)	0.5 (1.4)
San Mateo	0.8 (2.1)	2.4 (6.2)	3.2 (8.3)
Santa Cruz	0.9 (2.3)	0.9 (2.3)	1.8 (4.7)
Monterey	1.9 (4.9)	2.5 (6.5)	4.4 (11.4)
San Luis Obispo	1.4 (3.6)	1.5 (3.9)	2.9 (7.5)
Santa Barbara	0.6 (1.6)	1.9 (4.9)	2.6 (6.7)
Total	14 (35.7)	27 (70.6)	41(213.8)

Table 4. Average and maximum erosion distance in 2000 for cliffs and dunes, by county.

County	Dune Erosion		Cliff Erosion	
	Average Distance (m)	Maximum Distance (m)	Average Distance (m)	Maximum Distance (m)
Del Norte	180	400	160	520
Humboldt	160	600	61	260
Mendocino	190	440	33	160
Sonoma	150	320	41	190
Marin	140	270	110	240
San Francisco	150	230	90	220
San Mateo	230	430	31	220
Santa Cruz	170	340	36	130
Monterey	180	400	37	220
San Luis Obispo	140	330	78	280
Santa Barbara	190	320	54	240
Average	170	370	66	240

3. SEDIMENT SOURCES AND RECEIVER SITES

3.1 SEDIMENT SOURCES

Potential upland, coastal and nearshore, and offshore sediment sources exist for nourishment projects within San Luis Obispo County. Although some sediment quantity and grain size characteristics of these sources are known, information regarding material properties, timeframe of their availabilities and transport costs varies and continually changes depending on project-specific characteristics. The lists of potential sediment sources can be expanded depending on project preferences and as more information becomes available.

Upland sources include dams and reservoirs, known or anticipated construction sites with an excess of sandy material to be removed, and sand mining operations. Coastal and nearshore sediment sources include harbor and marina maintenance dredging projects (including bypassing and backpassing across harbor entrances, such as Morro Bay), wetland restoration and maintenance dredging projects, and river maintenance dredging projects. Offshore sediment sources generally consist of relic sand deposits, but these have not been comprehensively mapped for San Luis Obispo County.

3.1.1 Upland Sources

The primarily potential upland sediment sources are rivers, streams, and flood control projects –e.g., dams and retention and debris basins – where sediment may become available as a result of dredging to restore capacity. Other sources of opportunity are discussed where available.

WATERSHEDS, RIVERS AND CREEKS

Coastal watersheds within San Luis Obispo County are shown in Figure 7 and Figure 8 (San Luis Obispo Regional Water Management Group, 2014). Watersheds along the San Luis Obispo County coastline include: Big Creek – San Carpoforo Creek Area; San Simeon – Arroyo de la Cruz Area; Santa Rosa Creek Area; Cayucos – Whale Rock Area; Morro Bay; Irish Hills Coastal Watersheds; San Luis Obispo Creek; Pismo Creek; Arroyo Grande Creek; Santa Maria River; and Nipomo – Suey Creeks.

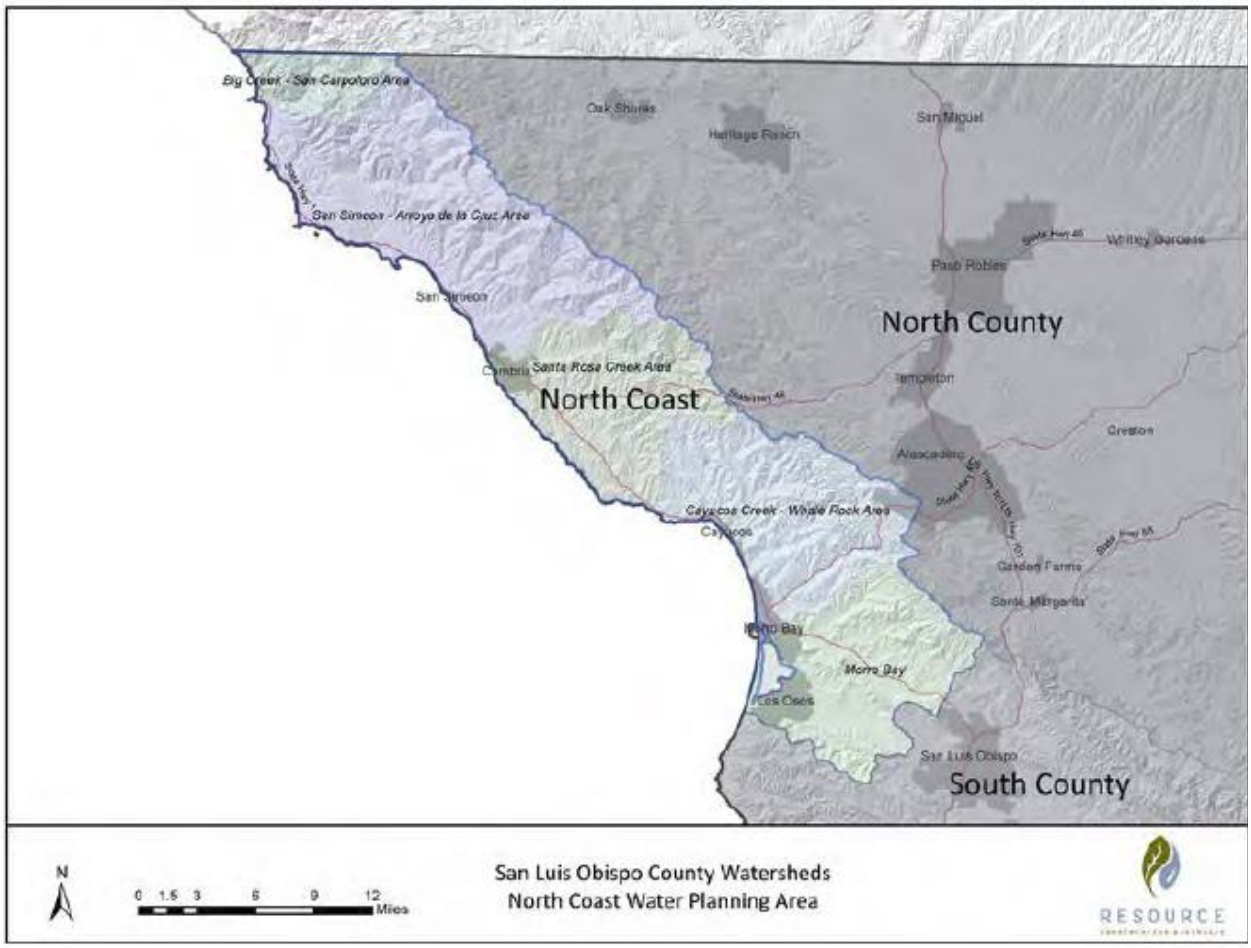


Figure 7. North County Coastal Watersheds

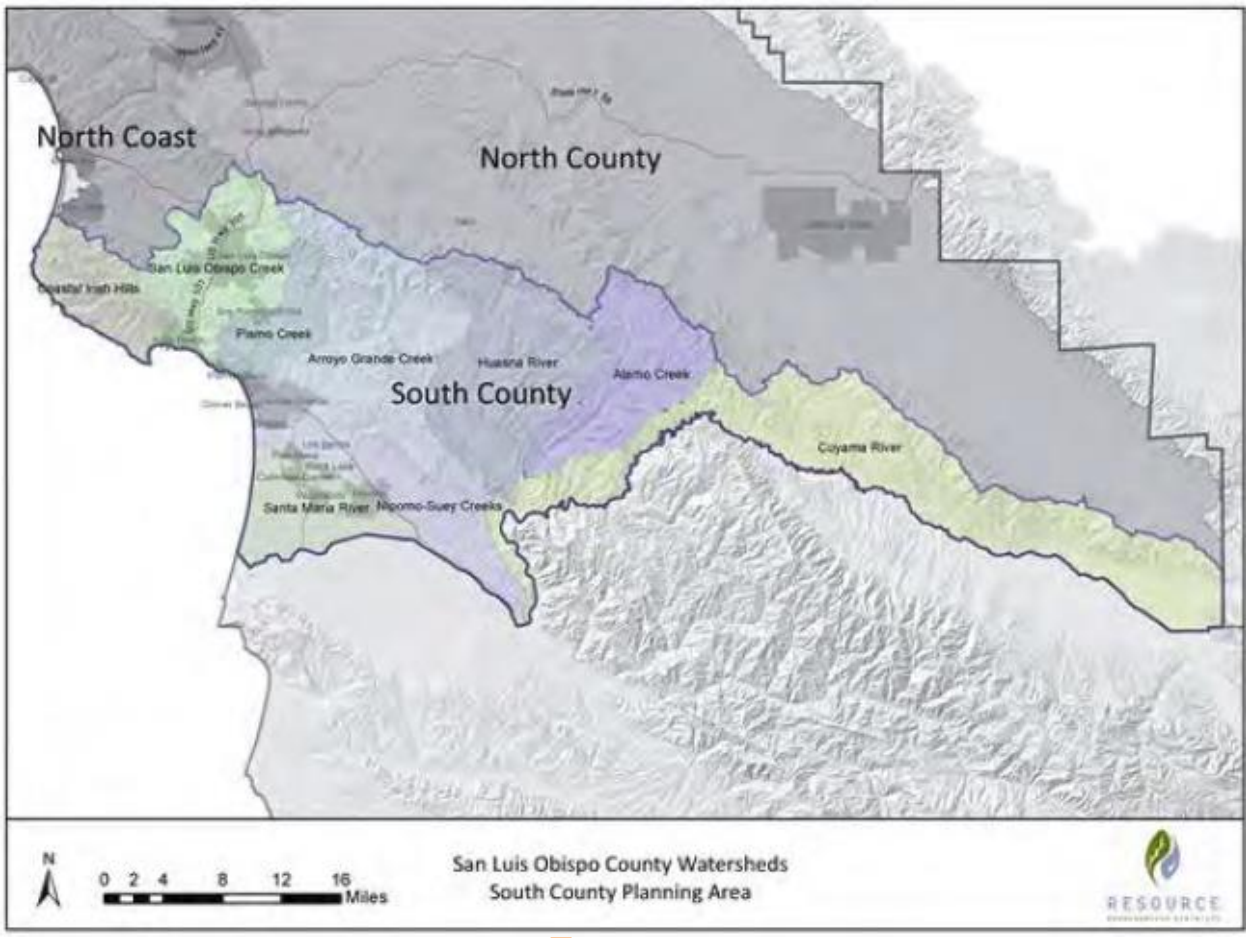


Figure 8. South County Watersheds

Although coarse, beach-sized sediment travels through watersheds, they are not typically the focus of watershed concerns. Once those sediments reach the coast they leave the watershed and enter littoral cells. Alternately, the term sedimentshed (Martin, 2005) focuses on sediment issues as the term watershed focuses on water issues. A sedimentshed is the area over which the lifecycle of sediment transport occurs, encompassing upland watersheds and coastal deposition areas in or outside the littoral zone. The sedimentshed concept would seem a logical approach for planning and regulating coastal regional sediment management issues.

The San Luis Obispo Regional Water Management Group (2014) reported on issues regarding sedimentation in each of the watersheds (Table 5. Watershed Management Issues

Watershed	Issue	Potential Causes
San Simeon - Arroyo De La Cruz	Excessive Sedimentation	Not stated
Santa Rosa Creek	Sedimentation	Grazing Cattle
Santa Rosa Creek	Fine sediment in lower reaches	Historical land clearing
Cayucos Creek	Sedimentation	Not stated
Morro Bay	Accelerated sedimentation	Natural, increased impervious area, lack of vegetation because of land management and fire
Coastal Irish Hills	Sedimentation and loss of riparian cover	Overgrazing
San Luis Obispo Creek	Instream Fish Habitat	Lack of riparian canopy and instream shelter, sedimentation of stream cobble
San Luis Obispo Creek	Streambank Stability (Erosion)	Development encroachment, channel incision, vegetation removal, overgrazing, agriculture, roads and utility construction
San Luis Obispo Creek	Upland Erosion and Sedimentation	Vegetation removal, intensified grazing, unpaved roads, and construction disturbances
Arroyo Grande Creek	Erosion and Sedimentation	Erosive, sediment free dam release, lowering base flow level, increased impervious areas, unvegetated roads and fields
Nipomo - Suey Creeks	Surface Water Quality	Erosion, Sedimentation, bacteria from wildlife, domestic animals/livestock and urban areas,
Pismo Creek	Erosion and Sedimentation	Drought/storm years weaken banks, agricultural practices
Santa Maria River	Presence of levees that restrict or otherwise modify flows, flow channels, and sediment transport corridors	Levees along Santa Maria River
Santa Maria River	Sediment accretion in the study reach and shoreline erosion	Twitchell Dam changes to sediment transport
Santa Maria River	Oso Flaco Lake – DDT and dieldrin	Undetermined, sediment
Cuyama River	Sedimentation of Twitchell Reservoir	Natural and upland erosion

). Sediment delivery rates from rivers, streams, and creeks to the littoral zones within the Plan area are compiled in Table 6. As can be seen, not all of the sediment delivery rates are quantified. This is not a problem, since these are in relatively undeveloped areas of the county operating under natural processes, and no changes in these areas are discussed in this CRSMP.

Table 5. Watershed Management Issues

Watershed	Issue	Potential Causes
San Simeon - Arroyo De La Cruz	Excessive Sedimentation	Not stated
Santa Rosa Creek	Sedimentation	Grazing Cattle
Santa Rosa Creek	Fine sediment in lower reaches	Historical land clearing
Cayucos Creek	Sedimentation	Not stated
Morro Bay	Accelerated sedimentation	Natural, increased impervious area, lack of vegetation because of land management and fire
Coastal Irish Hills	Sedimentation and loss of riparian cover	Overgrazing
San Luis Obispo Creek	Instream Fish Habitat	Lack of riparian canopy and instream shelter, sedimentation of stream cobble
San Luis Obispo Creek	Streambank Stability (Erosion)	Development encroachment, channel incision, vegetation removal, overgrazing, agriculture, roads and utility construction
San Luis Obispo Creek	Upland Erosion and Sedimentation	Vegetation removal, intensified grazing, unpaved roads, and construction disturbances
Arroyo Grande Creek	Erosion and Sedimentation	Erosive, sediment free dam release, lowering base flow level, increased impervious areas, unvegetated roads and fields
Nipomo - Suey Creeks	Surface Water Quality	Erosion, Sedimentation, bacteria from wildlife, domestic animals/livestock and urban areas,
Pismo Creek	Erosion and Sedimentation	Drought/storm years weaken banks, agricultural practices
Santa Maria River	Presence of levees that restrict or otherwise modify flows, flow channels, and sediment transport corridors	Levees along Santa Maria River
Santa Maria River	Sediment accretion in the study reach and shoreline erosion	Twitchell Dam changes to sediment transport
Santa Maria River	Oso Flaco Lake – DDT and dieldrin	Undetermined, sediment
Cuyama River	Sedimentation of Twitchell Reservoir	Natural and upland erosion

Table 6. River, Stream, and Creek Sediment Delivery

Name	Sediment Delivery (yd^3/yr)	Data Source
Big Creek, San Carpoforo Creek	Unknown	-
Arroyo de la Cruz	Unknown	-
Santa Rosa Creek	Unknown	-
Cayucos Creek	Unknown	-
Whale Rock, Old Creek	Unknown	-
Morro Bay	See coastal sediment sources, below	-
Irish Hills Coastal Watershed	2,000 – 6,000	1
San Luis Obispo Creek	7,300 – 8,000	1,2
Pismo Creek	Unknown	-
Arroyo Grande Creek	13,000 (35,000 – 300,000 tons/yr)	2,3
Santa Maria River	60,000	2

1) Everts Coastal, 2000; 2) Bowen and Inman, 1966; 3) Swanson Hydrology Geomorphology, 2006

DAMS AND RESERVOIRS

Dams and reservoirs impound significant quantities of sediment, much of which is beach quality sand. These dams and reservoirs could potentially be used as sediment sources for beach nourishment and other coastal sediment management activities. San Luis Obispo County contains numerous dams important to the total water and sediment budgets (Figure 9. The dams listed in **Error! Reference source not found.** have capacities greater than 1,000 acre-feet California Department of Water Resources, 2015; City of San Luis Obispo, 2015).

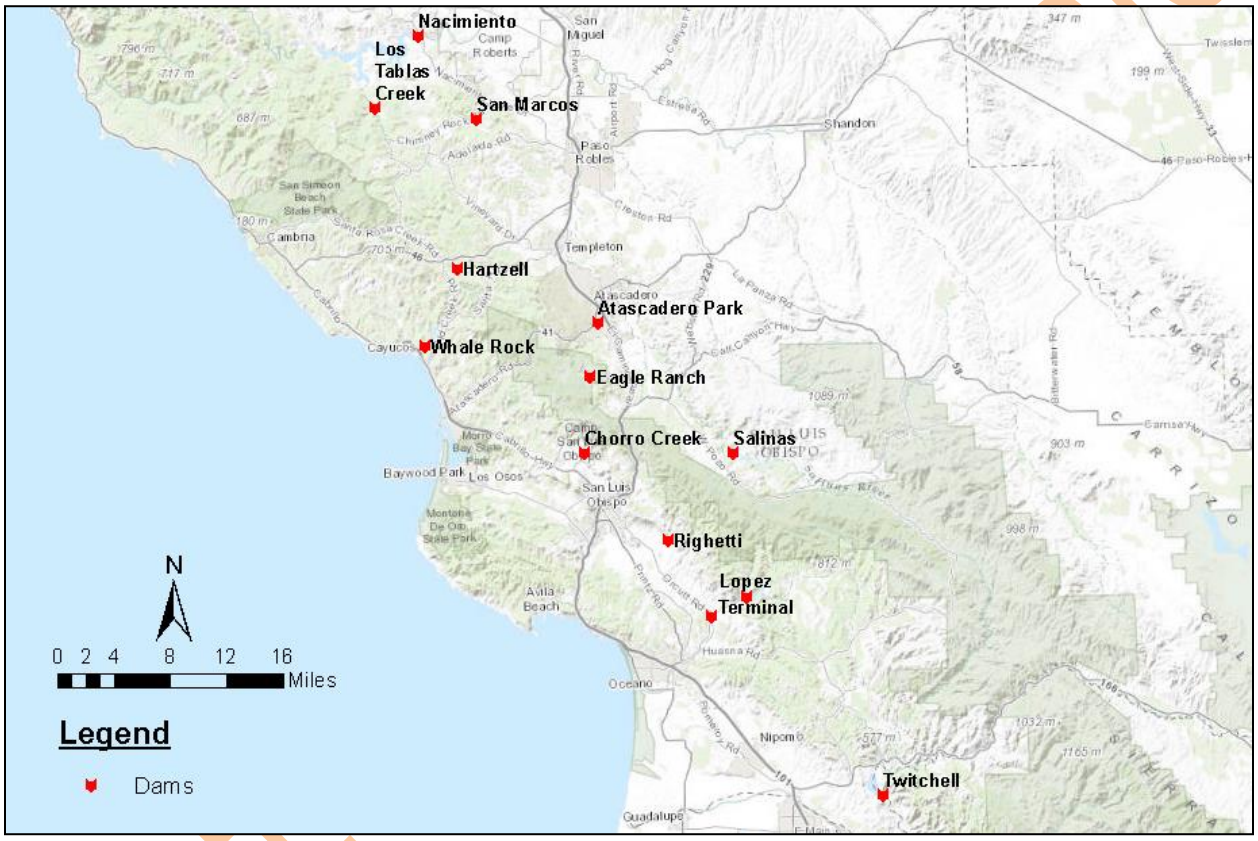


Figure 9. Dams and Reservoirs in San Luis Obispo County

Table 7. Large Dams in San Luis Obispo County

Lake Nacimiento	Nacimiento Dam	Nacimiento River	Monterey County Water Authority	1961	350,000
Lopez Lake	Lopez Dam	Arroyo Grande Creek	San Luis Obispo County Flood Control and Water Conservation District	1969	52,500
Santa Margarita Lake, Salinas Reservoir	Salinas Dam	Salinas River	U.S. Army Corps of Engineers	1942	24,000
Twitchell Reservoir	Twitchell Dam	Cuyama River	U.S. Bureau of Reclamation	1958	240,000
Whale Rock Reservoir	Whale Rock Dam	Old Creek	Whale Rock Commission	1960	39,000

Like all dams, those in San Luis Obispo County accumulate sediment over time, reducing their capacity. When dams and reservoirs need to be dredged or excavated to prolong their life, the sediment could be beneficially used in projects such as beach nourishment. Much of the accumulated sediment in California reservoirs tends to be silt or organic materials, which are much less applicable towards CRSMPs. Sedimentation problems at the county's dams are neither more nor less pronounced than other dams around the state. It appears that sedimentation is not inhibiting functionality of any large dam in San Luis Obispo County.

Nacimiento Dam: Originally constructed by the Monterey County Water Resources Authority, this dam and reservoir lies within San Luis Obispo County and the County has a water rights stake in the reservoir although most of the water goes to end uses in Monterey County. With a capacity of 350,000 Acre-Feet, this is the largest reservoir in San Luis Obispo County and the 21st largest reservoir in the entire State of California. Although the dam is well inland, salt-water intrusion is a recognized problem for the reservoir (lakelubbers.com, 2015).

Twitchell Dam: The spillways to Twitchell Dam empties into the Santa Maria River, which also forms the southern border between San Luis Obispo and Santa Barbara counties. The discharge reaches the Pacific Ocean at the south border of Oceano Dunes Park. Operated by the Santa Barbara Water Conservation District (SBWCD), the Twitchell Dam is both a flood control and water conservation dam. It stores floodwaters of the Cuyama River in Twitchell Reservoir, thus limiting potentially dangerous flows in the Cuyama, Sisquoc, and Santa Maria Rivers. The reservoir traps fine-grained clay, which suspends readily in moving water but settles to the bottom in the reservoir's still water. The accumulation of silt and clay in the reservoir reduces its capacity and, left alone, will eventually block the water inlet to the control gates. The SBCWD has excavated the sediment from around the inlet and plans on redoing so as necessary. Because this is an expensive process, they also use a method to flush some sediment downstream when opening the control gates. This procedure reduces the rate of sediment accumulation in the reservoir, but it deposits that sediment in the downstream channel, which creates the potential to block and divert the downstream flows.

As of 1998, the accumulated sediment in Twichell Resevoir had reached an estimated 44,000 acre-eet. To address this, the SBCCD and the Santa Maria Valley Water Conservation District are preparing a sediment management plan to extend the usable life of the reservoir. (Santa Barbara County Public Works, 2015).

Lopez Dam: The Arroyo Grande Creek watershed is located in the southwest part of San Luis Obispo County. At its Pacific Ocean terminus, the watershed is approximately 6 miles wide and drains through the sand dunes of Pismo State Beach and Oceano Dunes. The watershed covers approximately 150 square miles and extends approximately 16 miles inland. Nine miles upstream of the Pacific Ocean, Arroyo Grande Creek and watershed are transected by Lopez Dam, constructed in 1968. Lopez Lake has an estimated capacity of 49, 388 acre-feet (http://www.slocountywater.org/site/Water%20Resources/Data/Reservoirs/Lopez/). Runoff from the upper 60 square miles of watershed is captured behind the dam, creating Lopez Lake. Efforts are underway to quantify sedimentation at Lopez Dam (Coastal San Luis Resource Conservation District, no date).

Whale Rock Dam: This is a moderately-sized dam on Old Creek, near Cayucos which is popular with fishermen and hikers. The 40,000 acre feet reservoir provides drinking water to the City of San Luis Obispo and surrounding areas (City of San Luis Obispo, 2015).

Salinas Dam: This site is a popular county park including camping. A proposal is under consideration to raise the dam crest by 8 meters which was part of the original design.

The California Department of Water Resources (2015) lists eight other dams in San Luis Obispo County, with capacities less than 1,000 acre-feet: Atascadero Park Dam, Chorro Creek Dam, Eagle Ranch Dam, Hartzell Dam, Las Tablas Creek Dam, Righetti Dam, San Marcos Dam, and Terminal Dam. Although they are much smaller than those previously discussed, they likely retain significant quantities of sediment that may be useful for coastal regional sediment management.

Sand and Gravel Mining

By some estimates, the primary cause of sediment deficits in California beaches is not dams but sand and gravel mining (Magoon and Lent, 2005; Richmond et. al. 2007), with southern California losses averaging an estimated 20 million yd^3/yr (Kent et. al. 2005). There are an unknown number of legal sand mining operations near the San Luis Obispo County coast (partial list in Table 8) and most of these operate by removing sand and aggregate from or immediately adjacent to existing stream beds. Excluded from this list are mines that work off the Salinas River, which transport water and sediment to Monterey Bay, well outside this CRSMP area. A graphical, searchable database of mines in California is available from the California Department of Conservation (OMR, 2015).

Table 8. Sand and Gravel Mines within San Luis Obispo

Name	Operator, Owner	Watershed	Location
Cambria Pit	Windsor Construction	Santa Rosa Creek (Perry Creek)	Cambria
Coast Rock Products	Coast Rock Products	Santa Maria River	Santa Maria
Gordon Sand Company	Gordon Sand Company	Santa Maria River (Guadalupe Dunes)	W Main St., Guadalupe Dunes
Hanson Aggregates	Hanson Aggregates	Santa Maria River (Nipomo Creek)	Nipomo, Santa Maria, Sisquoc
Santa Maria River	City of Santa Maria	Santa Maria River	Santa Maria
Sisquoc Mining Operation	CalPortland Construction	Santa Maria River	Santa Maria

The lead agencies for these mines are either the City of Santa Maria or the County of San Luis Obispo. Additional oversight is provided by the U.S. Bureau of Land Management, California Department of Conservation, and California State Lands Commission. While mineral extraction fees are paid, no portion of these fees is applied to offset sand loss at the coast.

Sources of Opportunity

Surplus sources of sand that would otherwise be disposed of in a landfill, as construction fill, or offshore could be beneficially used to nourish eroding county beaches. There may be opportunistic sources within the county that could apply to coastal regional sediment management. Additional details of the statewide opportunistic approach are discussed in Section 4.5 of this report.

3.1.2 Coastal Sediment Sources

Potential coastal sediment sources include dunes, harbors and bays, wetlands, beaches, nearshore sites, and offshore sites. Many coastal sites of sediment accretion can serve as sediment sources for beach nourishment and other projects. Accretion sites that are not suitable as sediment sources are not discussed unless they are problematic in their own right.

Coastal Dunes

There are large sand dunes in the project area that have been used as sand sources in the past. Although they are not recommended as a sand source under the current project, their existence deserves some discussion. Approximately 125,000 yd^3/yr of sand migrates from the beaches to the Oceano Dunes and Guadalupe-Nipomo Dunes (Pismo Beach to Santa Maria River) through aeolian transport . Such transport represents a major sink for both the Morro Bay and Santa Maria Littoral Cells. Small particulate matter that is lost farther inland is currently being studied for human health impacts (San Luis Obispo County Air Pollution Control District, 2010). Larger grain-sized sand transport inland from the dunes is unknown.

MORRO BAY

Morro Bay is located 12 miles northwest of San Luis Obispo. Prior to the 1930s, Morro Bay was the home of a small commercial fishing fleet that was able to utilize the natural channels within the bay. Boats could enter from both the north side and south side of Morro Rock depending on the seasonal deposition of sand. In the 1930s, the Works Progress Administration built a seawall connecting Morro Rock to the mainland and thus eliminated boat access to the harbor from the north. The Morro Bay breakwater (Figure 10) was constructed by the USACE, Los Angeles District in the 1940s with U.S. Navy funds to provide a base for small patrol vessels. The breakwater was rebuilt in 1957 and again in 1964.

Recent work suggests that the Morro Bay Estuary is a sediment impaired coastal habitat (SICH); i.e. too much sediment is depositing within the bay (USACE, 2003; MBNEP, 2011; MBNEP, 2012). In 1975, the USACE estimated that 89.7% of the annual sediment deposition within Morro Bay came from littoral drift, 6.9% came from wind transport off the sand spit, and 3.4% came from creeks (City of Morro Bay, 2010).

In 2003, USACE found that excessive human-induced sedimentation is disturbing the habitats in Morro Bay. One possible solution would be to increase circulation and flushing in the bay by dredging sediment deposition areas. This sediment ranges from clay to fine sand and is distributed throughout the bay in complex physical and temporal patterns. The estimated maximum amount of material that could be dredged from the estuary is 2,000,000 yd^3 of mostly fine-grained silt (USACE, 2005b). Much of this material would not be available for dredging or suitable for nourishment projects. Sand transported by littoral drift is deposited in the entrance channel, and is currently removed through a maintenance dredging program. Aeolian deposition within the bay has been estimated at 8,000 yd^3/yr, and some of this material is likely sandy and therefore may be usable for nourishment. The USACE report indicates that no known toxic, radioactive, or hazardous waste sites are located in the Morro Bay Estuary, nor are there any major sources of pollution such as oil refineries, superfund sites, animal slaughterhouses, oil sumps, or waste pits in the study area. The USACE concluded that most dredging projects would be infeasible because of environmental impacts, regulatory restrictions, adverse public sentiment, and costs. Dredging will likely be limited in the foreseeable future to the ongoing maintenance of navigation channels and the State Park Marina (MBNEP, 2012). The most recent *Comprehensive Conservation Management Plan* (CCMP) by the Morro Bay National Estuary Program (MBNEP, 2012) states that while many sediment sources within the bay have been addressed, sedimentation within the bay is still excessive and complex, varying significantly over space and time.

From 1941 through 2014, dredged material from Morro Bay was disposed of at offshore locations south and north of the entrance (Table 9). In the table, Morro Strand State Beach (north of the entrance) is called Strand; Morro Dunes Natural Preserve and Morro Bay State Park (south

of the entrance) are called Sand Spit. Other disposal sites such as offshore and beach are unclear from the literature. Dredge sites within Morro Bay (proceeding inland) include the Entrance Channel, Navy Channel, Morro Channel Figure 10) and other smaller areas.

Table 9. Morro Bay Dredging History

Date	Disposal Site	Dredge Volume (yd^3)	Source
1941-1943	Strand	1,000,000	1
1942-1946	Strand	3,071,000	1,3
1949	Strand	822,000 – 822,400	1,3, 6
1956	Unknown	905,000 – 910,000	3, 6
1964	Strand	702,000	1,3, 6
1968	Strand or Upland	406,000 – 406,891	1,3, 5, 6
1971	Strand	190,000	1,3, 6
1974	offshore	350,000 – 352,100	3, 5, 6
1980	Beach	596,000 - 740,000	3, 5
11/84 – 2/85	Sand spit	50,000	1
11/84 – 2/85	Strand	450,000	1
1985	Strand	120,000	1
10/86 – 2/87	Sand spit	350,000	1
1987	Strand	400,000 – 460,000	1, 5, 6
9/90 -11/90	Strand	200,000	1
1990	Sand Spit	475,000	5
1992	Strand	125,000	5
8/93-12/93	Unknown	840,000	1
11/93 - 3/94	Strand, Sand Spit	600,000 – 637,000	1, 5
1995	Strand, Sand Spit	1040000	5
1997	Sand Spit	63,000	5
1998	Sand Spit	115,000	5
1998	Strand, Sand Spit	580,000	5
1999	Sand Spit	134,000	5
2000	Sand Spit	237,000	5
2001	Sand Spit	180,000	5
2002	Strand	868,000	5
2003	Sand Spit	171,000	5
2004	Sand Spit	156,000	5
2005	Sand Spit	134,000	5
July, 2006	Sand Spit	196,237	2, 5
June, 2007	Sand Spit	150,581	2, 5
June, 2008	Sand Spit	140,798	2, 5
June, 2009	Sand Spit	151,067	2, 5
2010	Strand	574,000	5
May, 2010	Sand Spit	249,780	2,4, 5
May, 2011	Sand Spit	120,919	2, 5
May, 2012	Sand Spit	125,073	2, 5
May, 2013	Sand Spit	122,850	2, 5
May, 2014	Unknown	171,709	2

Sources: 1) Coyne, 2000; 2) USACE, 2015c; 3) City of Morro Bay (?); 4) City of Morro Bay, 2010; 5) USACE, 2015b; 6) USACE, 1991

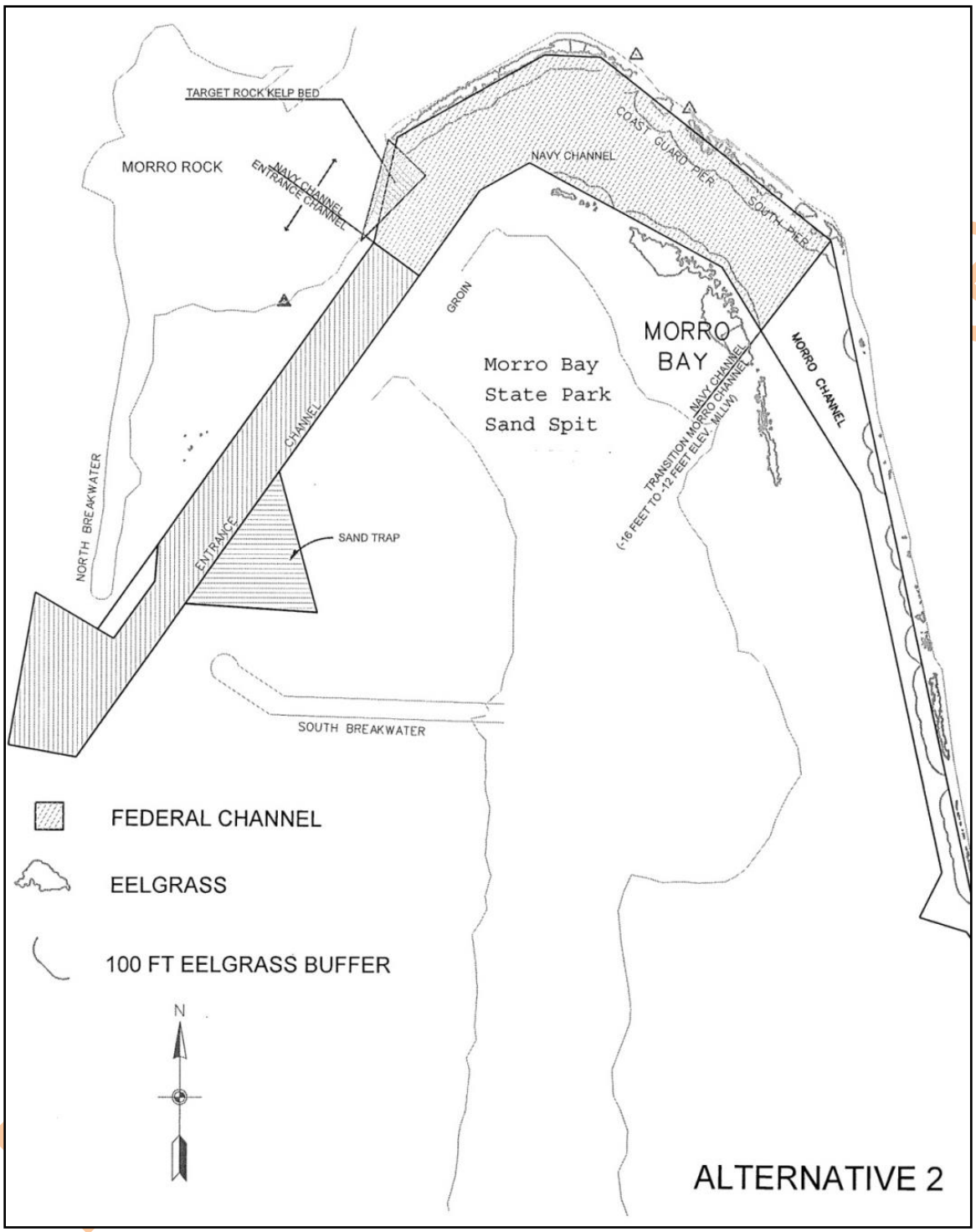


Figure 10. Morro Bay Dredge Areas (USACE, 2014a)

The average annual dredging rate from the 1940s to 1989 in Morro Bay was 120,000 yd^3/yr, with disposal at Morro Strand State Beach and Morro Bay State Park (Coyne, 2000). USACE (1991) predicted an annual dredging rate within the entrance channel of 115,000 yd^3/yr. The

average annual dredging rate from 2006 through 2014 was 185,000 yd^3/yr, which is reasonable because the dredging projects from 2006 to 2014 in some cases included all three channels

The State Park Marina within Morro Bay is a potential sediment source. In early 2010, there were plans to dredge from 50,000 to 60,000 yd^3 from within the marina with disposal planned for the nearshore Sand Spit disposal site (City of Morro Bay, 2010).

PORT SAN LUIS

Port San Luis is a small-craft harbor near the coastal community of Avila Beach. The original breakwater at Port San Luis is one of the oldest USACE Los Angeles District structures, dating back to before the 1900s. Significant repairs were made to the breakwater in 1936, and periodic repairs have been made since. Several attempts have been made over the years to expand Port San Luis to accommodate a complete small-craft harbor and commercial shipping but local interests have repeatedly rejected expansion plans. The USACE Los Angeles District provides intermittent support to maintain structures at Port San Luis.

Approximately 300,000 yd^3 of sediment accreted in the lee of the Port San Luis Breakwater between 1875 and 1996. This translates to an annual average rate of approximately 2,500 yd^3 deposited in deep water east and northeast of the end of the Port San Luis breakwater (Everts Coastal, 2000). This material may be useful as a coastal regional sediment source.

The historical solution to the sediment accretion within Port San Luis has been maintenance dredging. In 2008, the Port San Luis Harbor District applied for a coastal development permit from the CCC to dredge up to 250,000 yd^3/yr from the Port San Luis Harbor and place this material at nearby beaches (CCC, 2008). This permit was approved, and the Port has been dredging approximately 25,000 yd^3/yr under this permit. Port San Luis has historically dealt with shoaling through small-scale annual maintenance dredging. In the past, it has used its own work force and equipment consisting of a small submersible pump, suspended by a landslide crane, to transport dredge materials over short distances. This method is described as being effective, but because of the short reach of the pumping equipment, is limited to nearby and nearshore waters.

Table 10 shows the volume of material dredged from the Sport Launch and Mobile Hoist basins within Port San Luis dating back to 1972. Since the 2008 CCC permit application also mentioned siltation around Harford Pier, this location is also assumed to be a likely sediment source. The combined sediment load available from these areas is estimated at between 5,000 to 25,000 yd^3/yr.

Table 10. Port San Luis Dredging History

Date	Sport Launch Volume (yd^3)	Mobile Hoist Volume (yd^3)	Source
1972	1st maintenance dredging	-	1
1970s-1980s		40,000 – 50,000	1
1984	-	lst maintenance dredging, 1,000	1
1986		8,000 – 10,000	1
1994	3,223	3,282	1,2
1995	3,397	2,768	1,2
1996	3,751	3,711	1,2
1997	3,555	3,904	2
1997	1913	5737	1
1998	4,882	6,621	2
1998	4651	2886	1
1999	11,450	4,550	1
2/99-8/99	4,407	3,105	2
11/99-12/99	350	0	2
2000	3,410	3,563	2
2001	7,335	1,420	2
2002	4,465	965	2
2003	10,560	7,995	2
2004	7,507	4,620	2
2005	8,302	5,115	2
2006	17,605	6,551	2
2007	15,012	6,930	2
2008	9,660	8,085	2
Sources: 1) Everts Coastal, 2000; 2) CCC, 2008			

It has been suggested that moving the discharge beach farther away would increase the time required for sediment to travel back to the problem areas (CCC, 2008). Everts Coastal (2000) suggested construction of a sediment trapping groin or sediment capture trenches to reduce sediment influx to the Sport Launch and Mobile Hoist facilities. These have not been implemented because of lack of funds (CCC, 2008). There are plans and funds budgeted to extend the Mobile Hoist into deeper water, which is intended to reduce the dredging needs at this location.

CRSMP stakeholders have questioned the relationship between the breakwater and sedimentation issues. Everts Coastal (2000) discusses historical conditions, relationships between the breakwater and sedimentation patterns, and possible impacts from modifying the breakwater.

3.2 Coastal Erosion Sites

Developed areas of the San Luis Obispo coast which are important to tourism and other aspects of the county's economy are mostly limited to five locations: Cambria/Moonstone, Cayucos, Morro Bay, Port San Luis/Avila Beach, and Pismo Beach. Although specific examples of erosion problems inside San Luis Obispo County exist and should be considered, it should be noted that the vast majority of the county's shoreline is either protected from development (e.g., state parks and beaches), or else privately owned, often by agriculture. Thus, there is little coastal development or infrastructure compared to other counties such as those to the south. Flooding and erosion at these undeveloped beaches is usually not a threat to infrastructure or recreational beaches so natural processes continue without concern. Historical erosion and flooding at areas of concern are discussed below. Future erosion or flooding impacts associated with potential sea level rise is also discussed, where applicable. Historical flooding sites that are not relevant to coastal sediment management have not been identified. Areas with noted or observed beach erosion are shown in Table 11.

Table 11. Coastal Erosion Sites

Site	Need Beach Nourishment	Description	Source	Threatened Infrastructure
Piedras Blancas Realignment	No	Bluff erosion threatens highway. Realign 2.8 miles of State Route 1 inland from eroding bluffs.	Caltrans 2010a, 2010b	Road
San Simeon State Park	Not stated	None stated	Higgins et al., 2004	Road
Cambria	Not stated	Bluff erosion threatens residential properties. Many seawalls and riprap exist south of Moonstone Beach.	Griggs et al., 2005	Residential properties
Cayucos	Possible	Commercial area impacted storm waves and coastal flooding. Passive erosion of beach.	Higgins et al., 2004; Griggs, et al., 2005; Surfrider, 2014	Parking, roads, businesses, homes, beach
Shell Beach - St. Andrews Lift to Price Street	No	Erosion of steep bluff. Damage to lift station. Structural bluff protection likely	USACE, 2014b	Road, home, sewage lift station
Shell Beach - Price Street Pocket Beach	Yes	Street threatened by erosion of steep bluff.	CSMW, 2002	Road
Pismo Coast Village RV Resort	Yes	Damage from flooding and storm waves	San Luis Resource Conservation District, 2011	RV Resort

The CSMW WebMapper (CSMW, 2015) shows the shoreline erosion rates along the coast calculated by Hapke et. al. (2006) dating from 1942 to 2002. There were no areas with erosion greater than 3 feet within San Luis Obispo County. Erosion between 0 to 3 feet was common at places such as Cayucos, Morro Strand State Beach, Morro Bay State Park, Montañ de Oro State Park, Shell Beach, Pismo Beach, and Oceano Dunes. This historical erosion is neither necessarily significant nor indicative of future conditions.

3.2.1 Piedras Blancas Realignment

The project is within the coastal zone, adjacent to the Monterey Bay National Marine Sanctuary and the Piedras Blancas State Marine Reserve, north of the Piedras Blancas Lighthouse. The proposal is to realign 2.8 miles of State Route 1 up to 475 feet inland of the existing alignment. Construction and roadway grading commenced in January 2016. The project includes restoration of the existing highway to natural conditions, and restoration and enhancement of 12 acres of offsite state parklands to mitigate impacts to disturbed areas. Severe coastal erosion has been temporarily mitigated through placement of rock slope protection at the highway shoulder, and minor roadway realignment has occurred over the past 17 years. The project will protect the highway alignment for approximately the next 100 years and will provide for continued highway operation while recognizing the need for public access to the coastline and protecting sensitive resources (Caltrans, 2010a and 2010b). This project provides an example of managed retreat.

3.2.2 Hearst San Simeon State Park

In 2004, the CSMW developed a state-wide list of Sites of Important Coastal Erosion (Higgins et. al. 2004), the northernmost in San Luis Obispo County being San Simeon State Park. No further details are provided and review of literature and aerial photographs did not indicate the specific location of concern.

3.2.3 Cambria

Cambria neighborhoods include residential development up to the bluff edge with little to no existing beaches. The developed coastal area south of Moonstone Beach is in a high hazard zone. and nearly every individual parcel has either a seawall or riprap for protection at the bluff base (Griggs et al,. 2005).

3.2.4 Cayucos

The CSMW lists Cayucos as a Site of Important Coastal Erosion (Higgins et al,. 2004) without further detail. The Surfrider Foundation (2014) notes that, “shoreline structures (seawalls) threaten areas from Cayucos Pier to Chaney Avenue.” Their focus is a threatened loss of beach through passive erosion induced by fixing the back of the beach with hard structures. The threat of loss of private property is also acknowledged. The retreating bluff eventually has

the potential to threaten some to all of approximately 150 homes built on the low-lying bluff between the pier and Chaney Avenue. Griggs et al., (2005) noted that seawalls and riprap protect nearly every parcel along developed sections of Cayucos, except where small promontories of more resistant rock occur. Beach nourishment may be difficult in Cayucos because of the presence of nearshore hard substrate habitat.

3.2.5 Shell Beach

Erosion at the Price Street Pocket Beach in the Shell Beach community of Pismo Beach is the subject of a study moving towards a Federal solution under the USACE's *Pismo Beach Shoreline Protection Project* (USACE, 2008; Chambers Group, 2011, USACE, 2014b). A feasibility report was approved in 2012 and design work is underway. Project areas are shown in Figure 11. Alternatives may include rock revetments, shotcrete covering, and vertical walls of bluffs and sea caves in order to protect a sewage lift station, public roads, and private property. Beach nourishment was not recommended for these sites as it was determined that sediment would move downcoast too quickly to provide reliable bluff protection (Chambers Group, 2011).

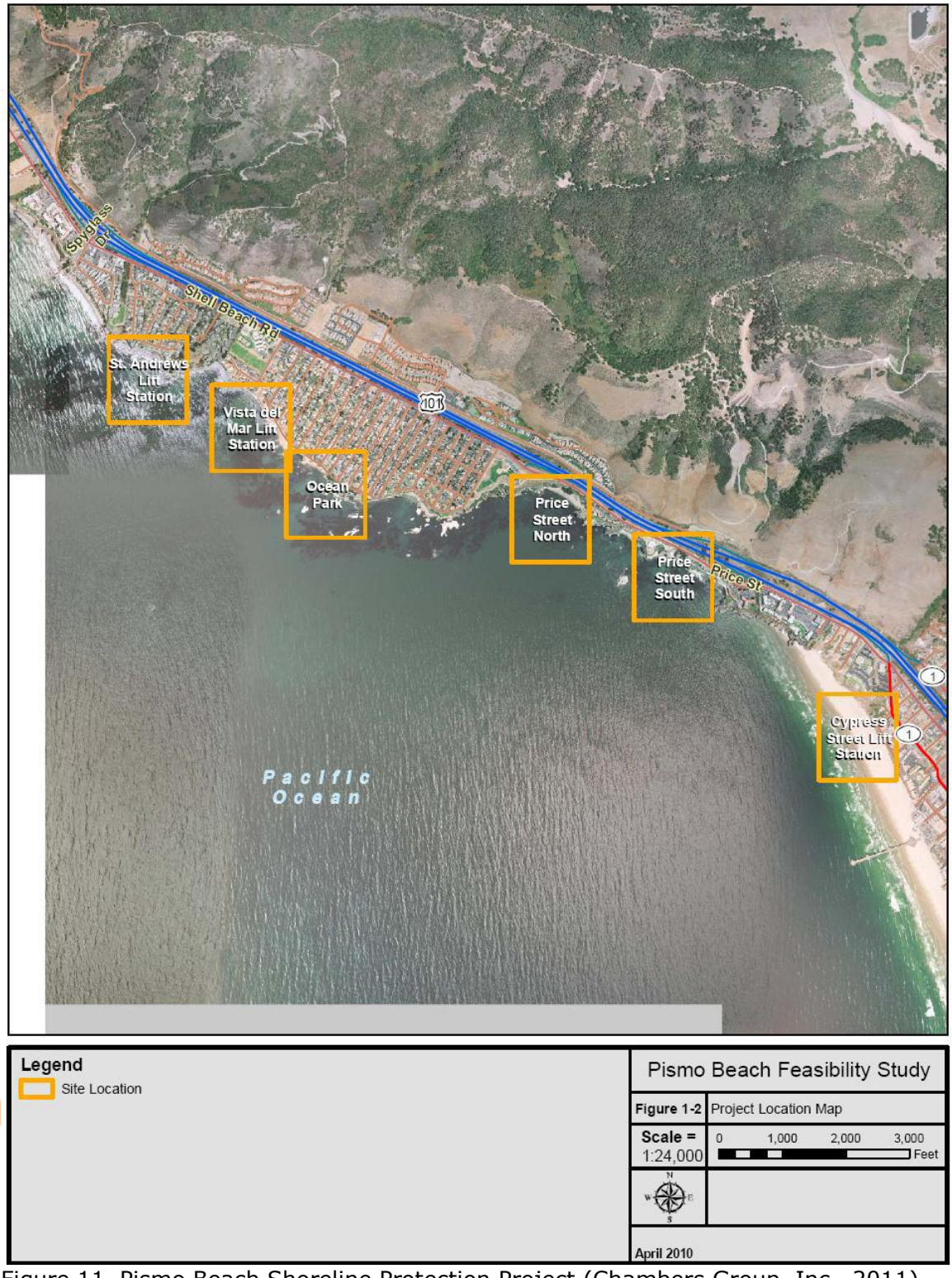


Figure 11. Pismo Beach Shoreline Protection Project (Chambers Group, Inc., 2011)

3.2.6 Pismo Coast RV Resort

Erosion of the Pismo Creek Estuary has been observed to threaten the barrier dune and the Pismo Coast Village RV Resort (Coastal San Luis Resource Conservation District, 2011). Numerous solutions have been proposed including:

- Live vegetation;
- Soft wooden structures;
- Hard rock structures with geotextile fabric; and
- Rapid sand replenishment program to maintain the dune after large erosion events.

3.3 Sea Level Rise Induced Flooding and Erosion

Various organizations have prepared estimates of future sea level rise impacts to the California Coast. Estimates by the Pacific Institute (2009) are most applicable to the current project, but other estimates are also discussed below.

3.3.1 Pacific Institute and CSMW WebMapper

Spatial data layers within the CSMW WebMapper that were developed by the Pacific Institute (2009) show areas estimated to be affected by future sea level rise (CSMW, 2015). Similar data can be viewed on the Pacific Institute online tool (Pacific Institute, 2009; Heberger et. al., 2009). This was a "bathtub" model comparing water elevations to ground elevation contours but ignoring hydrodynamics. An updated model has been created, but is not yet available for San Luis Obispo County (Battalio, 2015).

According to the layer labeled *Bluff Erosion Hazard 55-inch Rise – 2100*, all the bluffs in San Luis Obispo County are susceptible to sea level rise induced erosion. These include bluffs from the Monterey County border in the north through Cayucos, bluffs at Morro Rock, and bluffs running from Hazard Canyon, to Pismo Beach. In the layer label, 55 inches refers to the estimated maximum sea level rise above year 2000 highest observed water levels, by the year 2100. This estimate of sea level rise was recommended by working group of the Climate Action Team as of 2010 (CO-CAT, 2010). Various ranges of sea level rise values have been recommended since then (NRC, 2012).

The layer labeled *Dune Erosion Hazard 55-inch Rise -2100* shows all dunes in San Luis Obispo County being susceptible to sea level rise induced erosion. These include dunes from Cayucos to Morro Rock, Morro Bay State Park, Avila Beach, and a continuous dune stretch from Pismo Beach through Guadalupe-Nipomo Dunes and beyond.

According to the layer labeled *100-year flood 55 – inch Rise-2100* there are extensive areas that may be affected by a 100-year coastal flood in combination with a 55-inch sea level rise. Of note are the following developed areas:

- Balboa Avenue in San Simeon; Moonstone Beach Drive, Windsor Boulevard, and Sherwood Drive in Cambria;
- Downtown Cayucos, especially where development covers the floodplains of the Cayucos Creek;
- Morro Bay near the Morro Creek floodplain. Specifically on Atascadero Road, Morro Bay High School, the Morro Bay Sewage Treatment Plant, and the Morro Dunes RV Park. The sewage treatment plant is threatened, as corroborated in the literature and evidenced by the City's plan to move their sewage treatment plant a mile inland from its current location (City of Morro Bay, 2015; calcoastnews.com, 2014). This plan to move the sewage treatment plant away from the coast is an example of managed retreat as an adaptation measure to sea level rise.
- Mitchell Drive and Pasadena Drive in Los Osos;
- West end of Avila Beach, especially where development covers the floodplains of San Luis Obispo Creek;
- Pismo Beach, south-east of the pier, especially where development covers the floodplains of Pismo Creek. This includes the Pismo Coast Village RV Resort, Pismo Beach Mobile Home Park, and other downtown areas.
- Grover Beach and Oceano, especially where development covers the floodplains of Arroyo Grande Creek. This includes neighborhoods around and including the Oceano County Airport and including the South SLO County Sanitation District Wastewater Treatment Plant. This last area can be seen in a screenshot with flooded areas shown in orange in Figure 12

Figure 12. Screen Grab of 100-Year Flood with Year 2100 Sea Level Rise in Oceano (CSMW, 2015)

According to the layer labeled *Structures Vulnerable to 100-year 55-inch SLR*, the only structure shown as impacted in San Luis Obispo County is the South SLO County Sanitation District Wastewater Treatment Plant in Oceano, shown in Figure 12.

3.3.2 USGS Coastal Change Hazard Portal

Sea level rise impact estimates are available from the US Geological Service (USGS) Coastal Change Hazards Portal (Hammar-Klose and Thieler, 2001). The USGS also provides information on coastal change hazards during storms, beach morphology during extreme storms, short-term and long-term shoreline change rates, a coastal vulnerability index, and probabilities of coastal shoreline retreat. Since these data are developed on a national scale, they are less applicable than the data provided above on the CSMW WebMapper. The USGS has a more localized and accurate model called the Coastal Storms Modeling System (CoSMoS), but this model has not yet been applied to San Luis Obispo County (USGS, 2015).

3.3.3 Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) developed sea level rise flooding estimates for very specific FEMA based climate change adaptation purposes. For example, FEMA does not mandate the inclusion of estimated sea level rise for Hazard Mitigation Assistance project applications, leaving the decision up to the state or local community. FEMA has a tool called the Coastal Hazard Analysis Modeling Program (CHAMP) for calculation of specific sea level rise, water level, and wave combinations (FEMA, 2015a). FEMA also has an online resource for previously developed Risk Mapping and Assessment Planning (Risk MAP) (FEMA, 2015b). These tools are mostly irrelevant for San Luis Obispo County as most of the work focused on East Coast regions.

3.3.4 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration (NOAA) has a Sea Level Rise and Coastal Flooding Impacts online tool (NOAA, 2015) that overlays water levels at one-foot increments on existing topography. The tool allows for up to a 6-foot sea level rise over mean higher high water tide. This combination is approximately 3.7 feet higher than the highest observed water level (Table 2). While this combined water elevation is quite high, the levels shown by the Pacific Institute are higher and better illuminate future flood prone areas for purposes of this CRSMP.

3.4 Receiver Sites

Historical and potential sediment receiver sites (e.g., nourishment, disposal, or placement sites) are discussed below. Some of these receiver sites are erosional hot spots and future flooding locations while others are simply sites that were convenient for beneficial use of dredged material.

3.4.1 Historical Receiver Sites

3.4.1.1 Morro Bay

The USACE (1991) notes that the City of Morro Bay proposed that dredged material from the bay entrance rehabilitation project could be disposed at sites “1.5 miles north or 1.5 miles south of the bay entrance, located within the littoral zone.” These sites have been used in the past as shown in **Error! Reference source not found.** (CSMW, 2015) and Table 9.

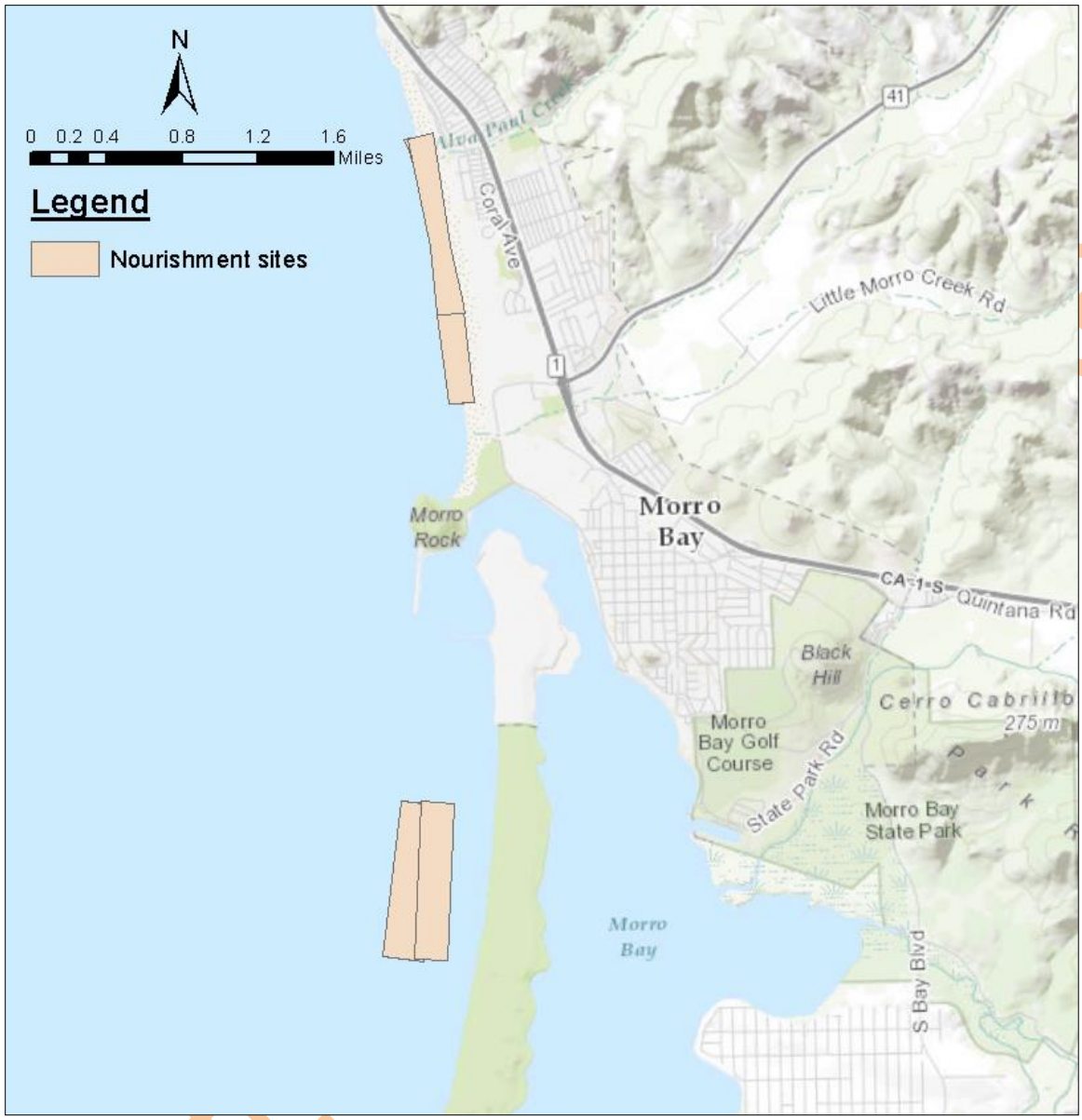


Figure 13. Historical Beach Nourishment Sites in Morro Bay

Beach placement at the southern site (i.e., Morro Bay State Park) is prohibited by the California Department of Parks and Recreation because of disruption of local wildlife, but nearshore placement is acceptable at this location. Beach placement at the northern site, Morro Strand, is acceptable.

3.4.1.2 PORT SAN LUIS

Everts Coastal (2000) suggested dredged sediment placement sites in order least exacerbate sediment accretion in the sport launch and boat hoist Luis. The most preferred placement site was south of Harford Pier (

Figure 14), as this is near the northern end of the littoral cell. The next preferred location was as far west of Olde Port Beach as possible and lastly, north of Fisherman's Beach. The 2008 CCC permit application by the Port San Luis Harbor District requested placement options at six beach and nearshore locations between Point San Luis and Avila Beach (Figure 14).

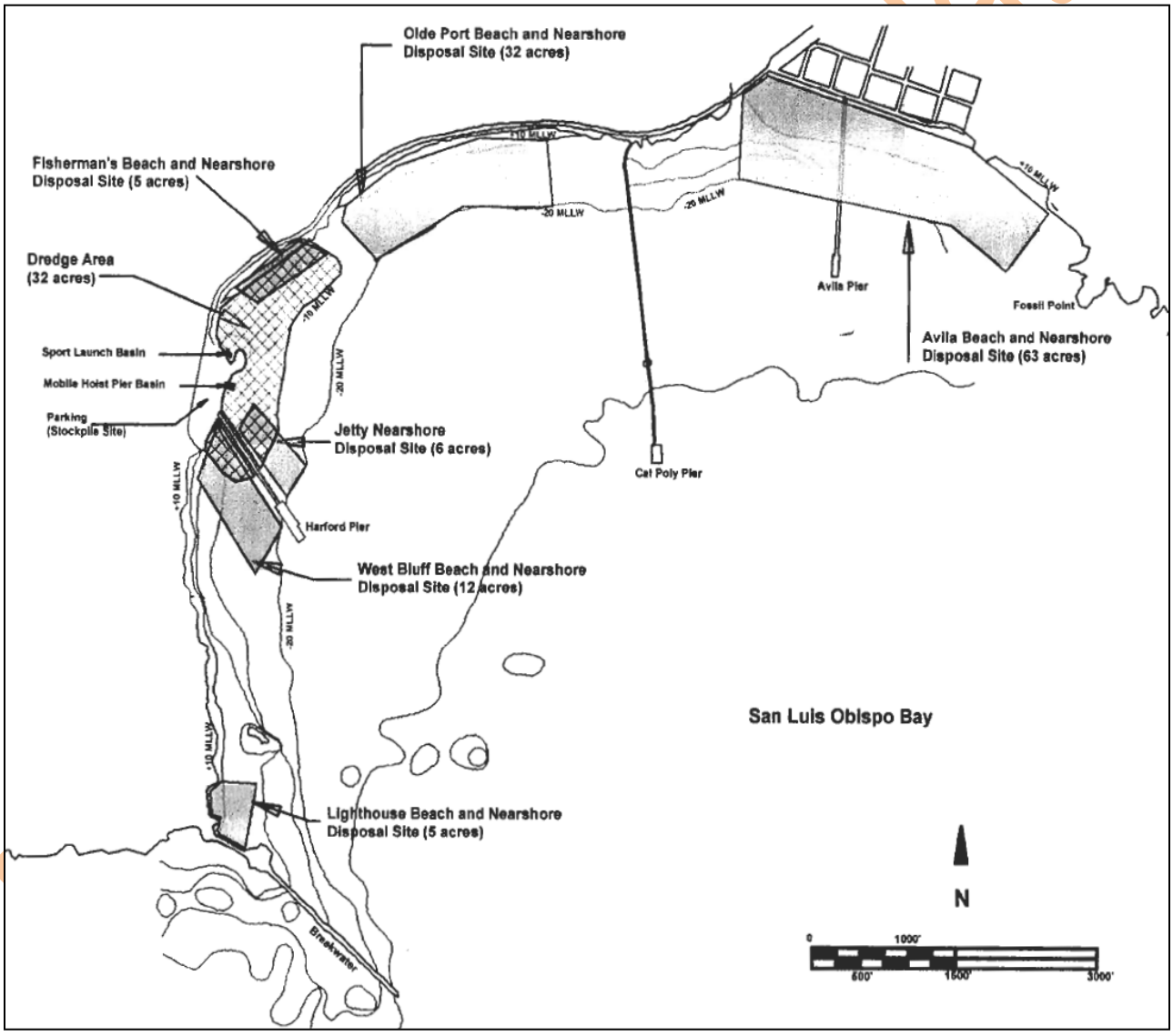


Figure 14. Potential Nourishment Sites in Port San Luis and Avila Beach (CCC, 2008)

3.4.2 Potential Receiver Sites

Potential sediment receiver sites that may support coastal regional sediment management are discussed below. These sites have not been reviewed under this CRSMP. Future investigation should include at a minimum: environmental impacts (direct and secondary), impacts to recreation and beach access, permitability, constructability, construction costs, potential benefits, community interest, and comparison with other alternatives.

For preliminary screening purposes, conceptual nourishment footprints of the below locations have been provided to the CRSMP team biologist for preliminary habitat impact analysis. These footprints were drawn in Google Earth Pro, with the primary intent of avoiding obvious hard substrate. Other project criteria (e.g., constructability) were not considered.

3.4.2.1 Cayucos

Nourishment at Cayucos State Beach and Cayucos bluffs may be desirable, using the ongoing Morro Bay maintenance dredging as a sediment source. Potential benefits may be protection of downtown infrastructure from winter storm flooding, and reduction of the bluff erosion rate. Specific challenges include sensitive hard substrate habitats that could be impacted from nourishment, and funding the incremental transport costs above and beyond the current Morro Bay dredging placement locations.

3.4.2.2 Port San Luis Disposal Sites

Staff from the Port San Luis Harbor District have suggested that their ongoing maintenance dredging activities could support coastal regional sediment management activities. In addition to the existing and already named dredged material placement sites, they wish to reconsider Pismo Beach nourishment sites. Some suggestions are discussed below.

The USACE considered nourishment at Shell Beach using its Continuing Authority Program, but that ideawas abandoned because of potential negative impacts to nearshore hard substrate habitat. There may be some small nourishment options possible at sandy stretches such as at South Palisades Park, Spyglass Drive, and the southeast end of Dinosaur Caves Park. This activity would require significant study including addressing constructability and direct and secondary environmental impacts.

Currently it does not appear that Pismo Beach requires nourishment, but with future sea level rise, the beaches will likely narrow. Early planning and preparation to mitigate this narrowing could take the form of nearshore nourishment, offshore stockpiling, or even beach or dune stockpiling. This activity would require significant study.

3.5 Sea Level Rise Adaptation

There are numerous areas in San Luis Obispo County that will likely be susceptible to sea level rise-induced flooding or erosion as described in Section 3.3 of this report. At this time, it would be premature to conclude that nourishment would be an appropriate solution. For example, flooding induced by sea level rise is expected at the floodplains for Cayucos, San Luis Obispo, Pismo, and Arroyo Grande Creeks, but nourishing the associated beaches and raising the beach berm may only serve to exacerbate fluvial flooding. A detailed study should be performed at each location to assess possible risks, costs, and benefits associated with sea level rise adaptation strategies.

4. REGIONAL SEDIMENT MANAGEMENT MEASURES

A management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives. Management measures, which are the building blocks of alternative plans, are categorized as non-structural and structural. Non-structural measures reduce risk by modifying the characteristics of the buildings and structures that are subject to the effects of erosion or modifying the behavior of people living in or near potential erosional areas. Structural measures reduce risk by modifying the characteristics of the erosion. Coastal communities have a number of options in dealing with coastal erosion. The CCC's Sea Level Rise Guidance Document (2015) lays out a number of options, none of them mutually exclusive (Figure 15).

- ACCOMMODATE: Property and structures near the coast can be engineered/adapted to accommodate for increased sea level rise and coastal storms. These options involve various solutions such elevating structures and roads, preparing wastewater infrastructure for flooding, etc.
- PROTECT**:**
    - *Hard Protection***:** Traditionally coastal armoring structures such as seawalls and revetments have been used to protect the shoreline. However, these structures often exacerbate erosion seaward and on either side of the structure, reducing or eliminating beaches and their recreational and ecological value .
    - *Soft Protection***:** Beach Nourishment is a common soft protection solution. Nourishment may be enhanced with hard structures such as groins or occasionally with offshore reefs.
- RETREAT**:** Accommodation, sometimes referred to as "managed retreat," involves allowing the coast to retreat naturally, often with legal restrictions on coastal property moving coastal property from private to public or quasi-public ownership over time.
- HYBRID SOLUTIONS: In practice, many communities may want to use a combination, or hybrid, of these adaptation strategies.

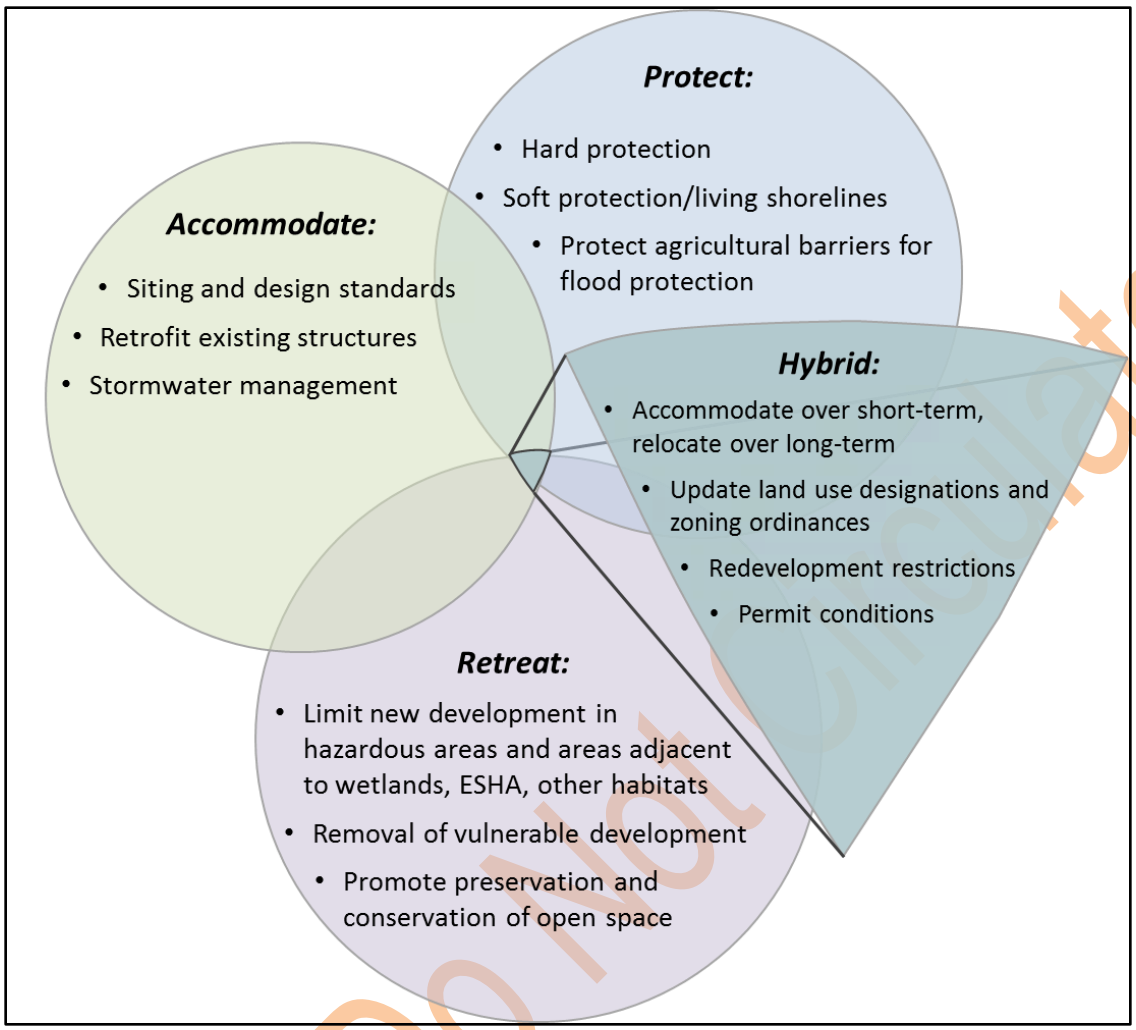


Figure 15. Strategies for adapting to Sea Level Rise (CCC, 2015).

With regard to coastal erosion, measures are often employed to reduce or refocus wave energy, direct water away from damageable property, or protect infrastructure. The following measures are deemed appropriate for erosion response along the San Luis Obispo coastline, but there are others that might be appropriate in specific areas.

4.1 Shoreline Protection and Armoring

It has been recognized by many agencies that protecting bluffs by using "hard" structures (e.g., seawalls, groins, and revetments) can often have adverse effects on natural sediment processes and associated impacts to public beaches. Although these adverse effects should be understood on a case-by-case basis, in general, the presence or the proposed need for hard armoring of the shoreline or bluff line are considered risk indicators for problems in coastal sediment management. Localities use their Local Coastal Plan (LCP) to help minimize the adverse effects associated with armored shorelines through the use of setback requirements on property development.

A study by Griggs et al., (1992) tallied shoreline armoring throughout the state. In 1978 approximately 0 percent of the San Luis Obispo County shoreline was armored by structures, and in 1988 this tally had risen only to 1 percent. The amount of shoreline armoring in San Luis Obispo County has grown since 1988 and is expected to continue to grow further with time. This CRSMP is being developed as a means to facilitate alternatives to such growth.

4.2 Setbacks

Construction and development setbacks can facilitate the beach's status quo, reducing the need for coastal protection, armoring, and nourishment. The San Luis Obispo County LCP contains language to "assure that new development will not result in future armoring of the shoreline" (San Luis Obispo County, 2001). The LCP requires a setback distance on any new development located adjacent to a beach or coastal bluff. The setback should be based on a local bluff or coastline erosion rate determined by geologic engineers applied over a 100-year structure life. A safety factor should also be incorporated to account for geologic uncertainty.

4.3 Beach Nourishment

Beach nourishment, also known as beach replenishment or beach fill, is the placement of mostly sand-sized sediment on the upper profile of the beach, sometimes extending into the surf zone, for purposes of widening the beach. The method typically utilizes hydraulic pumping of sand slurry, or truck/scraper dumping of sand on the beach, which would then be reworked by dozers. The process usually results in a temporarily wider and higher constructed beach berm, evolving to a longer-lasting but narrower equilibrium profile, and without retention structures in place, ultimately dissipating to the pre-construction state. Beach nourishment usually occurs on beaches that are chronically narrow and erosive, thus requiring repetitive nourishment to maintain the desired beach width. Beach nourishment is one of several instruments in the coastal regional sediment management tool box to address beach erosion.

4.4 Nearshore Nourishment

Nearshore nourishment, also known as nearshore fill or nearshore disposal, is the placement of mostly sand-sized sediment on the lower shore profile below the low tide line, normally within the depth of closure associated with the receiver site. The process usually results in a temporary nearshore sand mound, evolving to a longer-lasting equilibrium profile with some onshore sand migration widening the beach, and ultimately dissipating to the pre-construction state. Nearshore nourishment is an instrument in the coastal regional sediment management toolbox for addressing beach erosion in that beneficial use of sand sometimes entails placement in the nearshore.

4.5 Sand Compatibility and Opportunistic Use Program (SCOUP)

A California-wide opportunistic beach nourishment program, termed the Sand Compatibility and Opportunistic Use Program (SCOUP) for the San Diego County region was developed for the CSMW as a template to facilitate the development of local opportunistic sand programs in California (Moffatt & Nichol, 2006). Opportunistic use would allow or simplify the beneficial use of sand for beach nourishment that would otherwise be disposed of in a landfill or as construction fill. These efforts typically take the form of beach nourishment, but nearshore nourishment may qualify. The SCOUP provides this template by identifying relevant and appropriate:

- Jurisdictional regulatory agencies, required permits and informational needs;
- Specific considerations needed to establish and rank potential receiver sites within the littoral cell or other regional area;
- Types of anthropogenic activities that could produce viable potential sources of sediment if located within an economic distance of the receiver site;
- Testing protocols, criteria and checklists required to assess potential physical, chemical and biological impacts associated with the use of opportunistic materials, as well as establish compatibility between potential sediment sources and the approved receiver site(s);
- Project design considerations including maximum volume, placement techniques, placement rates and location (typically based on biological or recreational concerns), and transportation methods/impacts (often associated with disturbance of nearby residents and economic considerations);
- Biological and physical monitoring concerns and testing needed before, during and after project construction, as well as reporting requirements;
- Description of user steps required to successfully implement a regional opportunistic program, including additional informational needs and project design considerations when using less-than-optimum source sands; and
- Specific examples of ways to increase public education and awareness.

4.6 Stockpiling

The use of stockpiles for temporary storage of sediment can increase the flexibility of an opportunistic sediment source by both reducing costs and extending timelines. One example would be to place excavated construction sediment in a stockpile to await the time when an expected beach need arises, facilitating the construction schedule. Multiple events can be stockpiled, increasing the available volume of sediment, and once the receiver site becomes available, the stockpiled material can be moved to where it is needed. This method can also reduce permitting requirements since removing material from a temporary stockpile is relatively simple.

4.7 Sand Retention

Sand that is placed upon erosive beaches without some form of retention will likely move downcoast. Therefore, beach nourishment at highly erosive beaches can become more economical when combined with appropriate ways to retain sand. Traditional coastal structures such as groins and breakwaters have been used effectively to stabilize beaches in the past; however, their use in the future is unlikely to be favored. The challenge then is to find an effective sand retention methodology that is environmentally consistent with the policies of the San Luis Obispo County stakeholders. In response to this challenge, the Plan could seek ways to demonstrate and implement new and innovative sand retention technologies that are more compatible with the San Luis Obispo County coastal setting and provide multi-purpose benefits of beach preservation, biological enhancement, and increased recreation opportunities.

4.7.1 Reefs

Artificial reefs have been identified as potential sand retention devices that would be compatible with permitting agencies, improve recreational opportunities, and increase hard bottom habitat. Narrowneck Reef in Australia is a recent example of a sand retention reef that did not achieve expectations, but research is ongoing. At this time, there are no functioning artificial reefs on the California coast.

4.7.2 Dewatering

Beach face dewatering is defined as the lowering of groundwater within the beach to increase natural accretion processes. This dewatering is based on the principle that the less saturated a beach face is when a wave swashes up onto it, the more water can infiltrate into the beach and less water is available to carry sand particles back down with the backwash, resulting in a net deposition of sand on the shoreface. Dewatering can either be active, with pumps and pipes, or passive, relying on gravity flow through buried pipes. These dewatering technologies are relatively new and unproven in shoreline management within California.

4.7.3 Soft Solutions

There are many sand retention approaches that are considered soft solutions in that they are not constructed of rock or concrete. Beach planting is a common soft solution applied on the Gulf and Atlantic coasts. Use of geotextile sand-filled bags is considered a semi-soft solution in that the structures function similar to their hard counterparts, but are considered more temporary and removable.

4.8 Managed Retreat

Managed retreat uses removal or relocation of threatened development to address erosion. With threatened structures moved away from the water, beaches and sand dunes can eventually

become the primary tool to slow erosion. While not common, there are examples in San Luis Obispo County, such as at the ongoing Piedras Blancas Realignment Project and the proposed Morro Bay Sewage Treatment Plant relocation.

5. BIOLOGICAL RESOURCES

5.1 SAN LUIS OBISPO COUNTY COASTAL BIOLOGICAL RESOURCES

The San Luis Obispo County nearshore zone includes part of the Monterey Bay National Marine Sanctuary (MBNMS) and several managed areas and protected habitats. These areas include State Marine Conservation Areas (SMCA), State Marine Reserves (SMR), State Marine Recreational Management Area (SMRMA), state parks and beaches, and state game refuges. They include ecologically significant habitats where endangered or threatened species may occur, designated critical habitat, nesting sites, foraging areas, and over-wintering areas. In addition, major haul out or roosting areas of fully protected species or important nursery or spawning areas of state-managed fishery species also are considered sensitive biological resources in this document. The county hosts a variety of species, including more than ten cetaceans (whales, dolphins and porpoises), four species of pinnipeds (seals and sea lions), otters, numerous fish species, and resident birds. Being located on the Pacific flyway, it also serves as a temporary home to several migratory birds.

Coastal sediment management options, such as beach nourishment and sediment retention structures, have the potential to affect habitats and species in a variety of ways. In addition, removing sand from aquatic and upland sources also has the potential to adversely affect biological resources in the vicinity. Many of the biological and natural resources are protected by various federal and state environmental laws and regulations. As such, compliance with these environmental laws and regulations is required prior to undertaking sediment management activities.

The county was divided into four regions: North, North-Central, South-Central, and South. Figure 16 through Figure 20 provide details of the habitats within each region, including: the shore type (i.e., sandy beach, rocky shore, hardened or constructed shorelines); managed and protected areas (e.g., SMCA, SMR, and state parks, reserves); coastal rivers and streams; kelp canopies; estuaries; and critical habitat. These figures are referenced throughout this section when discussing the various habitats and species present in the Plan area. In addition, Figure 21 through Figure 23 provide close-up versions of the figures to better depict biological resources in the vicinity of beaches of interest and potential sediment sources (Table 17). All spatial data are available for viewing on the CSMW WebMapper (CSMW, 2015).

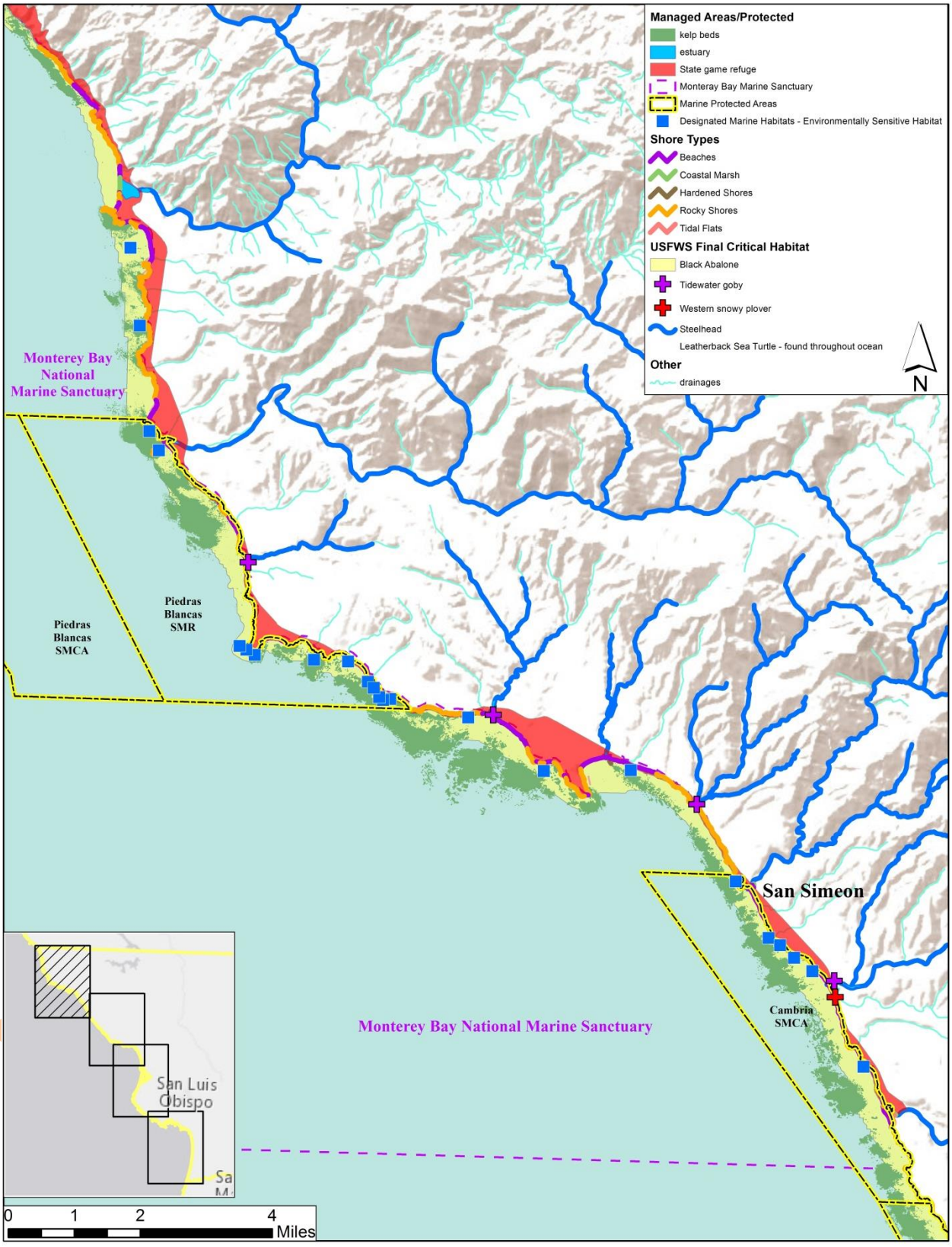


Figure 16. North San Luis Obispo County Biological Resources.

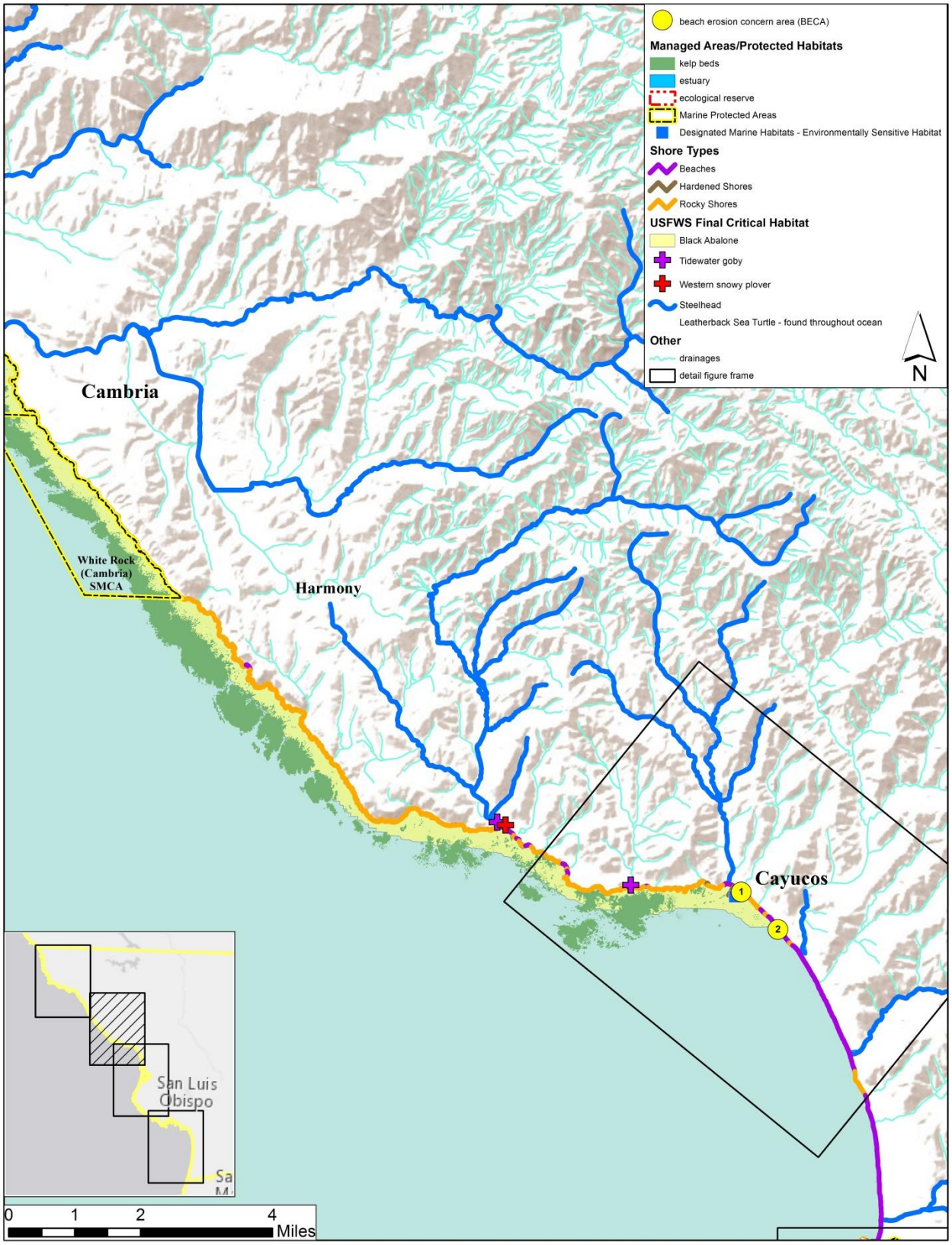


Figure 17. North-Central San Luis Obispo County Biological Resources.

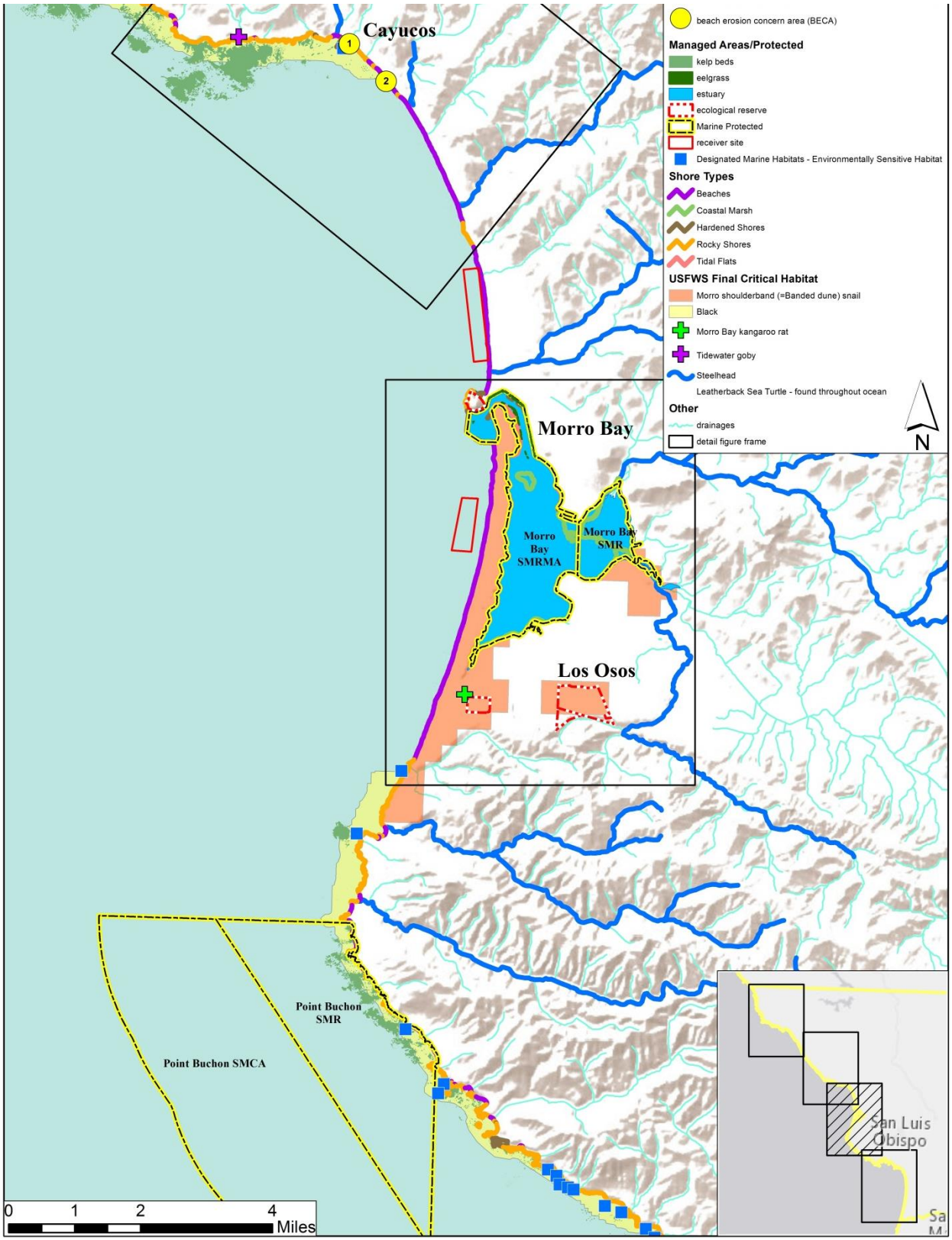


Figure 18. South-Central San Luis Obispo County Biological Resources.

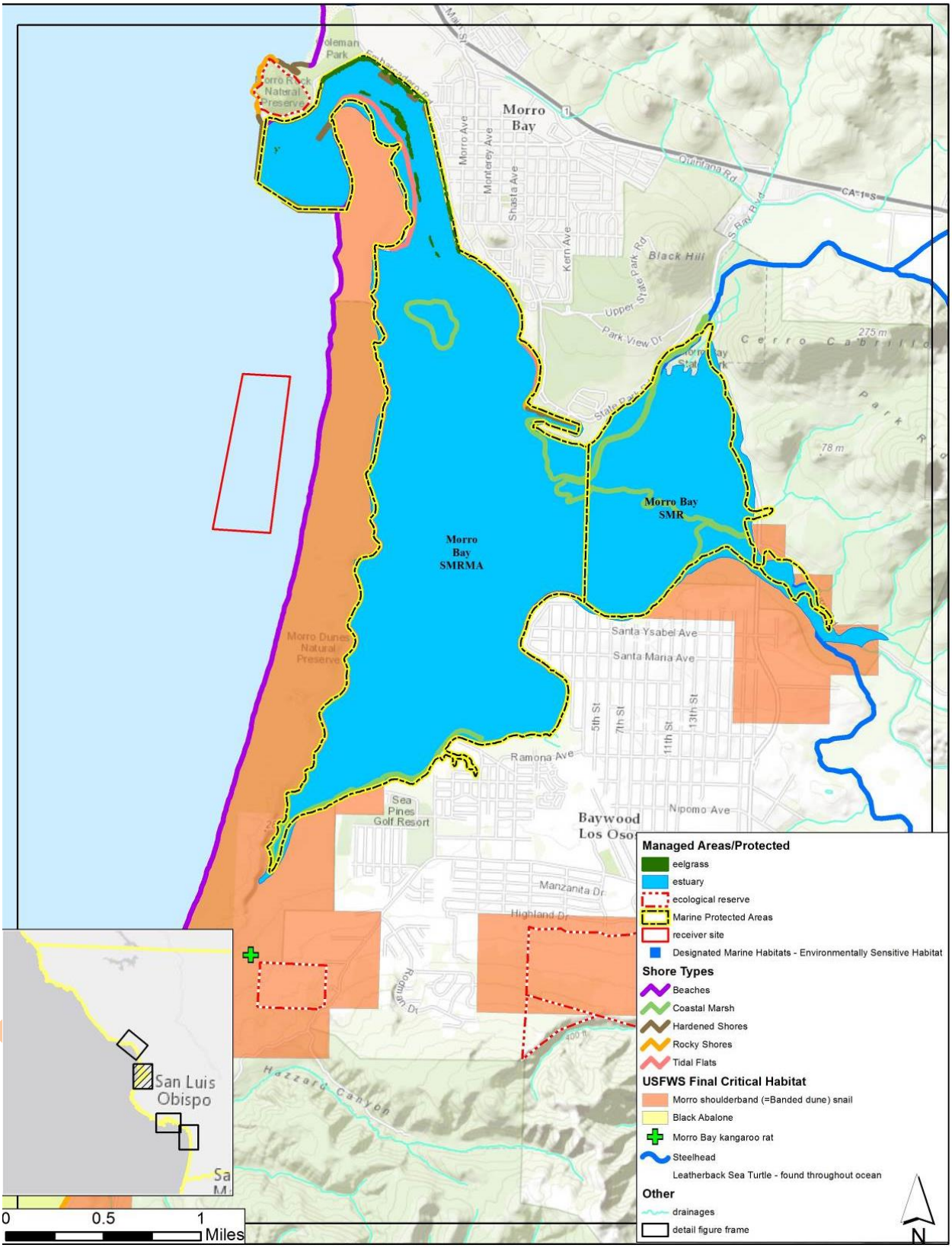


Figure 19. Biological Resources in Vicinity of Morro Bay.

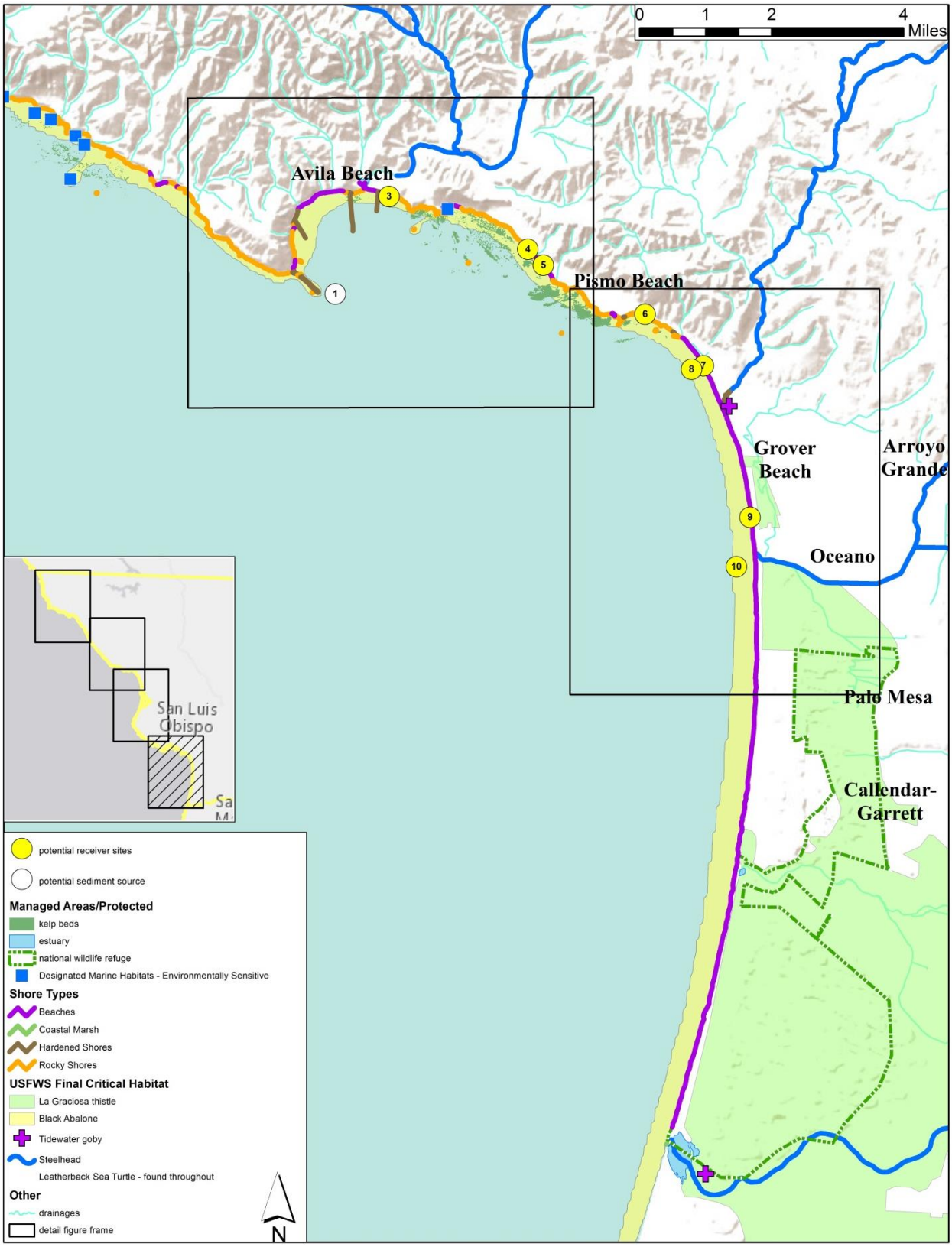


Figure 20. South San Luis Obispo County Biological Resources.

Figure 21. Biological resources in the vicinity of beaches of interest in North-Central San Luis Obispo County.

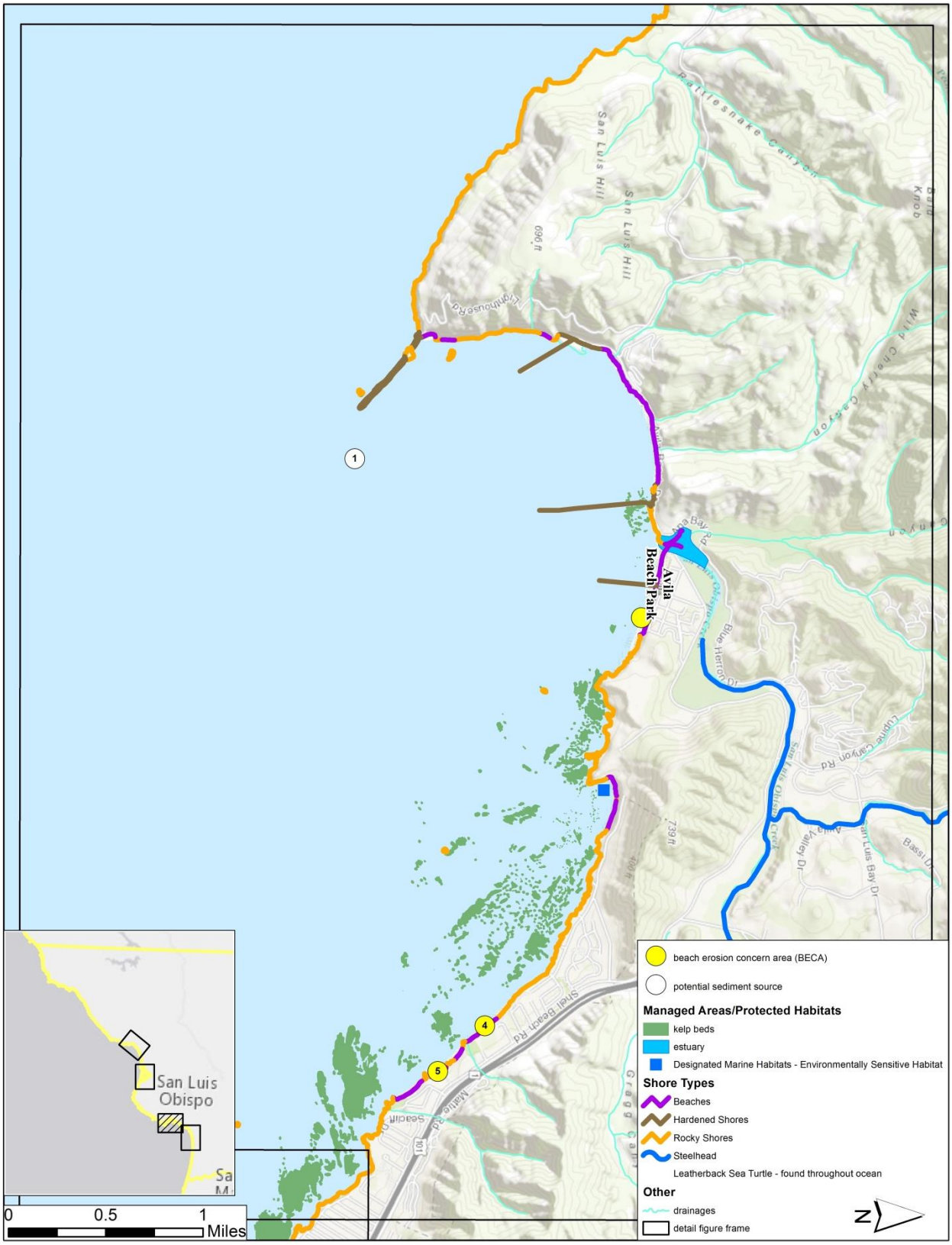


Figure 22. Biological Biological resources in the vicinity of beaches of interest in South San Luis Obispo County.

Figure 23. Biological Biological resources in the vicinity of beaches of interest in South San Luis Obispo County.

5.2 HABITATS OF SAN LUIS OBISPO COUNTY

The coastline of San Luis Obispo County includes a variety of habitats including sandy beaches, subtidal soft-bottom, rocky tide pools, offshore reefs, bays, estuaries, and harbors. In addition, vegetated habitats such as kelp beds and seagrasses (eelgrass meadows, surfgrass beds) have localized occurrence in rocky and embayment areas. Several of these habitats are considered sensitive habitats or support sensitive resources. Federally designated habitat areas of particular concern (HAPCs) include the following: estuaries, canopy kelp beds or forests, seagrasses, and rocky reefs. Several state marine protected areas (MPAs), which provide additional regulatory protection of biological resources, occur along the San Luis Obispo County coast. Many marine mammals are present year-round or temporarily migrate through the offshore habitat. Many of these habitats are protected by various environmental laws, including, but not limited to, the federal Clean Water Act, Coastal Zone Management Act, Endangered Species Act, and Magnuson-Stevens Fishery Conservation and Management Act; and the state Porter-Cologne Act, Endangered Species Act, and California Coastal Act.

5.2.1 Sandy Beaches, Coastal Dunes, and Strands

Sandy beaches, which are in a zone that extends between MHHW and MLLW, include both intertidal foreshore and the dry backshore areas. This habitat is dynamic with constantly shifting sands resulting from wave action, tidal forces, and longshore transport. Sandy beaches are characterized by lower productivity when compared to adjacent intertidal habitat (NOAA 1992). Beaches with sufficient sand support a variety of resource uses and recreational values including sunbathing, walking, wading, and various beach sports. These areas may support recreational fishing.

The northern portion of the county contains smaller, pocket beaches (**Error! Reference source not found.**), while larger sandy beaches are more common in the central and southern portions of the county (**Error! Reference source not found.** to **Error! Reference source not found.**). Sandy beaches provide primary habitat for invertebrates; forage, resting, and nesting habitat for birds, including the threatened western snowy plover and endangered California least tern; and spawning habitat for California grunion, which spawn between March and September. Macrophytic wrack (e.g., algae, kelp, and seagrasses that have washed ashore) provides nutrients for invertebrates and a secondary foraging base for birds, such as gulls and plovers. Snowy plovers overwinter and nest on sandy beaches within San Luis Obispo County (Table 12) and designated critical habitat is present along the northern portion of the county (Figure 16). In addition, California least terns utilize and nest on sandy beaches within the county (e.g., Morro Dunes, Oceano Dunes), and harbor seals and northern elephant seals are known to haul out on beaches along the north coast; a major elephant seal rookery is located just south of Piedras Blancas.

Table 12. Overwintering Plover Monitoring Results for 2014 at Select San Luis Obispo County Beaches.

San Carpoforo Creek	Observed
Point Sierra Nevada	None
Arroyo de la Cruz	None
Sidney's Lagoon	None
Point Piedras Blancas	None
Arroyo Laguna	Observed
San Simeon Creek	Observed
Villa Creek	Observed
Morro Strand State Beach	None
Morro Bay Sand Spit	Observed

Source: California State Parks 2014

Coastal sand dunes are terrestrial habitat dominated by vegetated and unvegetated sandy mounds (Figure 24). Dunes are formed from wind blowing sand (aeolian transport) with the sand accumulating in drifts and becoming stabilized by vegetation. These habitats are typically present in areas landward of the extreme high water line where rocky shores are not dominant. The beach backshore, which occurs landward of MHW, may transition to dune habitat. Coastal dune and strand habitat support numerous of species of plants, insects, reptiles, birds, and mammals, including several special status species, and provide shoreline stability, protection from winter storms, and contribute sand to the coastal zone (SIAC, 2007).

Figure 24. Dunes at Montana de Oro State Park, San Luis Obispo County. Photos from Simms 2010.

Coastal strands are the vegetation that grows on the beach backshore or foredune areas. Coastal strand vegetation is adapted to areas affected by strong winds, waves, and salt spray. Typically, vegetation diversity in these areas is rather low, but increases landward. Examples of tolerant plant species in San Luis Obispo County include sand verbenas (*Abronia* spp.), beach saltbrush (*Atriplex leucophylla*), beach bur (*Ambrosia chamissonis*), and non-native sea rocket (*Cakile maritima*) (Simms 2010). Non-native vegetation further reduces the plant diversity of coastal strands, and examples of non-native and invasive vegetation includes European

beachgrass (*Ammophila arenaria*), iceplant species (*Carprobrutus* spp. and *Mesembryantheum* spp.), pampas grass (*Cortaderia sellonana*), and ripgut brome (*Broums diandrus*).

Special status plants associated with coastal dune and strand habitat are present in the San Luis Obispo County, and include the endangered La Graciosa thistle (*Cirsium scariosum* var. *loncholepis*) which has designated critical habitat at Oceano Dunes (Figure 6), as well as, others plant species such as salt marsh bird's-beak (*Chloropyron maritimum* ssp. m*aritimum*).

Coastal dunes and strands are particularly vulnerable to human impact, including beach recreation, beach grooming, development, and hardened shoreline protection. In addition, dune erosion resulting from wind and waves can adversely affect this habitat. Expansive sand dunes are present at the Morro Dunes and Oceano Dunes Natural Reserves (Figure 21and Figure 23).

5.2.2 Coastal Rivers, Creeks, and Estuaries

There are numerous rivers and creeks in San Luis Obispo County that empty into the ocean, many of which serve as critical habitat for salmonids and tidewater goby. The mouths of rivers and creeks form estuaries and adjacent wetland habitat where salmonids rear and gobies are present during all life stages. At times, some rivers and creeks may be cut off from the ocean by sand bars. Table 13 provides an overview of the rivers and creeks (from north to south) that flow into the ocean within San Luis Obispo County, as well as, notes if they are designated critical habitat for sensitive species.

Table 13. San Luis Obispo County Rivers and Creeks.

Creek/River	Figure	Designated Critical Habitat
San Carpoforo Creek	15	Steelhead
Arroyo De Los Chinos	15	None
Arroyo de la Laguna Creek	15	Steelhead
Arroyo Del Oso	15	Steelhead, Tidewater Goby
Oak Knoll Creek	15	Steelhead, Tidewater Goby
Arroyo del Puerto	15	Steelhead
Little Pico Creek	15	Steelhead, Tidewater Goby
Pico Creek	15	Steelhead
San Simeon Creek	15	Steelhead
Santa Rosa Creek	15, 16	Steelhead
Ellysly Creek	16, 17	Steelhead, Tidewater Goby. Western Snowy Plover
Villa Creek	16, 17	Tidewater Goby
Cayucos Creek	16, 17	Steelhead
Toro Creek	16, 17	Steelhead
Little Morro Creek	16, 17	Steelhead
Morro Creek	16, 17	Steelhead
Chorro Creek	17, 18	Steelhead
Los Osos Creek	17, 18	Steelhead
Islay Creek	17	Steelhead
Coon Creek	17	Steelhead
Pecho Creek	19	None
San Luis Obispo Creek	19	Steelhead
Pismo Creek	19	Steelhead, Tidewater Goby
Arroyo Grande Creek	19	Steelhead
Santa Maria River	19	Steelhead

5.2.3 Coastal Wetlands

Coastal wetlands include all lands within the coastal zone that are periodically or permanently covered with shallow water. Coastal wetlands include saltwater marshes, freshwater marshes, brackish marshes, swamps, mudflats, and fens. Wetlands are typically present near the mouth of rivers and creeks, and adjacent to estuaries.

5.2.4 Estuaries

Estuaries are some of the most productive habitats in the world. They provide critical habitat for some life stages of several plants, fish, shellfish, and other organisms. Bays, sloughs, and associated wetlands, which provide a variety of habitats (e.g., open water, mudflats, eelgrass beds, marshes, salt flats, and pannes) and may support thousands of species of plants, invertebrates, fish, amphibians, reptiles, birds, and mammals (CDFG 2001, Coastal Conservancy 2001). These habitats are considered important nurseries for marine fish, nesting and foraging areas for resident and migratory birds, and critical habitat for several threatened and endangered species, including tidewater goby and salmonids. Estuaries also provide spawning and rearing habitat for several commercially important species, such as herring, halibut, and Dungeness crab.

Estuaries support a variety of recreational (bird watching, educational activities, hiking, boating, fishing) and commercial (commercial fishing landings, mariculture, shipping) uses (CSMW 2012a). Mouths of creeks, esteros, lagoons, rivers, and sloughs provide ecologically important connections between watersheds and the coastal zone. Estuary mouths also serve as inlets that bring tidal exchange to coastal wetlands and as outlets for storm water runoff, nutrients, and sediment supply to the coastline. Invertebrates inhabit inlet sediments, anadromous and marine fish may transit inlets to reach estuarine and riverine spawning and foraging areas, and shorebirds and fish-eating birds forage within inlet areas . Morro Bay is the largest estuarine habitat in San Luis Obispo County.

5.2.5 Inlet Embayments

Coastal inlet embayments typically form estuaries, which provide some of the most ecologically productive and heavily used recreational areas in the state. Coastal ports, harbors, and marinas are often located in quiescent sections of larger bays or along natural indentations of the coastline. These areas have a relatively deep-water connection to the ocean and provide more protected habitats than the open ocean because of headlands, structural breakwaters, and distance from the open ocean . These protected embayments support hundreds of species, including a variety of invertebrates, fish, aquatic vegetation, fish-eating birds and waterfowl, and transient occurrence of marine mammals (CCC 1987, Allen 1999, MEC, 2000b, Thompson et al. 2000).

San Luis Obispo County has only two harbors – Morro Bay Harbor and Port San Luis Harbor. Morro Bay Harbor is located in the south-central portion of the county (Figure 18, Figure 19, and Figure 21), and is a natural embayment with an artificial harbor constructed by the U.S. Army Corps of Engineers. It is the only all-weather small craft commercial and recreational harbor between Santa Barbara and Monterey. Morro Rock was originally surrounded by water, but the Army Corps of Engineers built a large artificial breakwater and road across the north end of the harbor, linking Morro Rock and the mainland. Port San Luis Harbor was formed by a natural outcrop on the west, Point San Luis, and man-made breakwater to the south (Figure 20 and Figure 22). Starting in the 1890's, large chunks of Morro Rock were blasted with dynamite and those boulders were brought to Port San Luis on a barge towed by a tug boat. The construction of the breakwater started in the 1890's and continued up until around 1913.

5.2.6 Littoral Habitats

Littoral habitats are found in the nearshore waters off the continental shelf, from the high water mark (typically MHW) to a depth of approximately 660 feet. Littoral habitats include the supralittoral or spray zone, which is just above the high water mark; eulittoral or intertidal zone, which is regularly inundated, and the sublittoral zone, which extends from the eulittoral zone to the continental shelf.

5.2.7 Sublittoral Habitats

Sublittoral habitats include the nearshore waters from the intertidal zone to a depth of approximately 660 feet. Much of the sea floor in this area comprises unconsolidated mud and sand with some areas of hard bottom and rocky outcrops near shore. Nearshore hard-bottom substrate is more common in the northern portion of the county (Figure 16), and in the vicinity of Point Buchon in the south-central portion of the county (Figure 18).

Species composition and diversity of marine resources associated with soft substrates differ with sediment type, which often varies according to depth and energy gradients. The nearshore zone of the sublittoral zone is relatively shallow, and waves and currents interact with the sandy bottom causing sands to shift with coarser sediments settling closer to shore. Fewer species of invertebrates live in sandy sediments in the shallow energetic nearshore zone than in the finer sandy to mixed sediments offshore, probably because of greater sediment stability offshore (Oliver et al. 1980, Thompson et al. 1997).

The deeper areas of the sublittoral zone experience less wave action, resulting in finer sediments settling on the seafloor. This area is characterized by more stable, fine sands and sediment with a significant amount of mud. The benthic communities are composed of polychaete worms and other sessile and suspension feeding organisms. Benthic fish are also more abundant in the deeper sublittoral zones with finer sediments, compared to the shallower areas with coarser sands.

Pelagic organisms found in this habitat include several species of plankton and zooplankton, squid, octopus, salmon, albacore, rockfishes, mackerel, anchovy, and marine mammals. California sea lions, harbor porpoise, sea otters, and several species of whales are often observed in this area (NOAA 1992). Important fisheries are associated with soft bottom habitats (e.g., Dungeness crab, halibut, Washington clam), but generally yield less overall commercial catch value than hard bottom or pelagic fisheries (CDFG 2001 as cited in SAIC, 2007). Marine birds also feed in this habitat.

5.2.8 Intertidal Zone

The intertidal zone, also known as the foreshore, is the area that is regularly inundated during high tides and exposed during low tides. The intertidal zone is either rocky or sandy, both of which abound in the littoral cell. The size of the intertidal zone is not fixed; rather, it varies with tidal range and the slope of the shore, and steep shorelines generally have a smaller range of intertidal rocky habitat.

5.2.8.1 Sandy Intertidal Zone

Sandy intertidal zones are characterized by soft bottom sands, shells, and occasionally cobble in the area between the highest and lowest tides. Sandy intertidal zones provide important habitat

for various organisms living under the surface of the sand, including clams, crabs, and other invertebrates. This habitat also serves as an important feeding ground for invertebrates and shore birds. California grunion use suitable sandy beaches as spawning habitat (Figure 25), and the threatened snowy plover nest, forage, and winter on certain beaches (Figure 26).

Figure 25. California grunion spawn on sandy beaches.

Figure 26. Western Snowy Plover (Chardrius alexandrinus nivosus). Photos from Simms 2010.

5.2.8.2 ROCKY INTERTIDAL ZONE

Rocky intertidal habitat occurs on rocky substrate between the lowest and highest tidal water levels (Figure 27). Rocky substrate habitats are capable of supporting hundreds of species of plants, invertebrates, and fish (Pequenat 1964, Abbott et al. 1980 as cited in SAIC, 2007). The most productive reef habitats are characterized by a variety of substrate relief and vegetation that provide important shelter and living space functions. In contrast, sand-scoured, low-lying reef and cobble substrate support little marine life (Ambrose et al. 1989, MEC 2000a, SAIC 2006). Organisms inhabiting this habitat include: red, brown and green algae; sessile invertebrates such as mussels, barnacles and anemones; mobile grazers and predators, including crabs, amphipods, littorine snails, limpets, sea stars, sea urchins, and abalone. Tidepool fish include the striped surfperch, tidepool sculpin, tide pool snailfish, and cabezon. In the littoral zone area, rocky intertidal habitat is critical habitat for black abalone.

Figure 27. Rocky Intertidal Habitat.

The physical habitat is very dynamic, with tides constantly changing the water level and waves continuously breaking on and washing over the organisms and substrate. Organisms inhabiting rocky tidal zones are exposed to air and inundated by sea water daily. When the tide is in and waves are crashing down, stationary organisms can be dislodged and removed from their rocky homes. When the tide is out, organisms desiccate (dry out) and are more visible to predators. The organisms present in this habitat are able to withstand the periodic desiccation, high temperature and light, low salinities, and strong wave action typical of this habitat (NOAA 1992).

Mobile animals prevent desiccation by finding tide pools, vegetation, or crevices in rocks to reside until the tide comes back in. Non-mobile organisms anchor tightly to the rocks and either close their shell structures or find other ways to prevent desiccation. Mussels close their shells during low tide and sea anemones fold inward to prevent drying out and to protect against predation.

Rocky tidal habitat is further characterized by zonation, which is defined by the amount of time rocks are exposed to air and water (Figure 27). Zones include the splash zone, upper intertidal, mid-intertidal, and lower intertidal. Zonation is determined by wave action and tidal range, physical tolerances, larval settlement, organism behaviors, intra- and interspecies competition, and predation and algal grazing. Each zone is associated with different water-air exposure ratios and species composition:

Splash zone: The splash zone – or supratidal zone – is the most upland zone. It is typically only splashed by waves, and organisms are rarely fully inundated. Organisms present in the splash zone are typically cyanobacteria and barnacles.

Upper tidal zone: The upper tidal zone is exposed to air most of the time, and species inhabiting this area have adapted unique life histories to survive. Barnacles are the most abundant species in this zone. Competition for space is typical in this zone.

Mid-intertidal zone: The mid-intertidal zone is densely populated. Mussels are the most abundant species, forming large beds anchored to the rock and adjacent mussels. Other species that may be present in tide pools in this area include sea stars, crabs, urchins, anemones, and other organisms. Competition for space is common in this zone, particularly between barnacles and mussels.

Lower intertidal zone: The lower intertidal zone is exposed to air only during the lowest ebb tides (i.e., spring tides), and organisms must be able to withstand continuous wave force. This zone is characterized by having the most species richness of all rocky intertidal zones. Green anemone, purple sea urchins, crabs, sea stars, abalone, and other invertebrates are commonly found in this zone. Seaweed and surfgrass is also present in this zone.

Well-developed, rocky intertidal habitats also support recreational activities such as tide pooling and fishing and diving. Hard-bottom species (e.g., California lobster, rock crab, sea urchins, octopus, sea cucumber, sheephead) account for the high value of commercial landings in these habitats as well (CDFG 2001, as cited in SAIC, 2007).

5.2.9 Rocky Subtidal

Rocky subtidal habitat is a highly productive, diversely populated habitat. It is home to several species of rockfish, algae, crustaceans, mollusks, and other marine organisms. Shallow rocky subtidal areas serve as important black abalone critical habitat. Much of the rocky subtidal habitat in the littoral cell is characterized by dense kelp forests, comprised of giant kelp (*Macrocytstis pyrifera*) or bull kelp (*Nereocystis luetkeana*).

5.2.10 Kelp Forest, Eelgrass, and Surfgrass

Three submerged aquatic vegetation (SAV) habitats of special interest in California coastal waters are: kelp forests and beds, surfgrass beds, and eelgrass meadows . The SAV habitats provide important sources of organic matter, substrate, shelter, and nursery functions for many species . Often, hard-bottom surfgrass (*Phyllospadix* spp.) and kelp-bed habitats are located inshore and offshore of each other, respectively, on the same reef system . Eelgrass grows in soft-bottom substrate. More species of invertebrates and fish are typically associated with SAV than non-vegetated habitats (Fonseca et al. 1991, Hoffman 1996, MEC 2000b).

Surfgrass is typically found between the intertidal zone and waters approximately 16 feet deep; however, it can grow in waters up to 50 feet deep. Surfgrass beds are highly productive areas supporting invertebrates and many species of algae, and they also provide nursery habitat for commercially important California spiny lobster, shelter for a variety of invertebrates and fish, and forage habitat for birds (Stewart and Meyers 1980, DeMartini 1981 as cited in SAIC 2007). Surfgrass beds are found throughout the littoral zone in areas of rocky shores and outcrops (Figure 28).

Figure 28. Rocky Intertidal Habitat with Surfgrass (Phyllospadix spp.)

Kelp beds grow in waters just beyond the breaker zone to depths of about 100 feet (Figure 29). They support hundreds of species of invertebrates and fish, many of which are prey for marine mammals (Foster and Schiel 1985). Kelp forests provide habitat for encrusting animals such as sponges, bryozoans, and tunicates, as well as for juvenile fish, mollusks such as abalone, algae, and other invertebrates. Kelp forests are the primary foraging area for southern sea otters. Fish associated with kelp beds include greenling, lingcod, bocaccio, and many species of surfperches and rockfish. Gray whales have been reported to feed near kelp forests and to seek refuge in them from predatory killer whales (Baldridge 1972 as cited in NOAA 1992). Kelp also provides a food resource for fish and for grazing and detritus feeding invertebrates, such as isopods and sea urchins. Predators, such as sea stars and sea otters, are also active there. Harbor seals and sea otters are also commonly associated with kelp forests in this area (NOAA 1992).

Figure 29. Giant Kelp (Macrocystis pyrifera) Forest.

Two species of kelp grow in the San Luis Obispo County littoral zone – giant kelp (*M. pyrifera*) and bull kelp (*N. luetkeana*). Kelp beds are present in the nearshore waters throughout the littoral cells, but are more common in the northern portion of the county, from the northern

border to Cayucos where rocky substrate is more readily available (**Error! Reference source not found.**), and then again in the vicinity of Point Buchon (Figure 18). Smaller kelp beds are also present on rocky substrate between Avila Beach and Pismo Beach (Figure 20).

Eelgrass (*Zostera marina*) meadows occur on soft substrates in protected coastal areas, mainly embayments, but also may occur in the nearshore where suitable conditions exist . In San Luis Obispo County, eelgrass beds are present in Morro Bay (Figure 19 and Figure 30). Any in-water construction likely to impact eelgrass habitat must be surveyed per the Southern California Eelgrass Mitigation Policy (SCEMP) (NMFS 1991, revision 11). The SCEMP is administered by the USFWS, NMFS, and CDFW to determine impacts to eelgrass resources. In accordance with the requirements of the SCEMP, a pre-construction eelgrass survey shall be completed by a qualified biologist within 60 days prior to initiation of demolition or construction activities at the site. This survey shall include both area and density characterization of the beds. A post-construction survey shall be performed within 30 days following project completion to quantify any unanticipated losses to eelgrass habitat. Impacts shall then be determined from a comparison of pre- and post-construction survey results. Impacts to eelgrass, if any, would require mitigation as defined in the SCEMP. If required following the post-construction survey, a mitigation planting plan shall be developed, approved by NMFS, and implemented to offset losses to eelgrass.

Figure 30. Eelgrass (*Zostera marina*) in Morro Bay.

5.3 Managed Areas

There are several state- and federally-managed areas in San Luis Obispo County including State Marine Conservation Areas, State Marine Reserves, state beaches, and state parks. Several beaches of interest identified in this document may be present within or adjacent to some of these managed areas. In addition, future sediment management activities not identified herein may become part of the SLO County CRSMP. Activities conducted in managed areas may require additional permissions (e.g., environmental approvals or permits). This section discusses the state-managed areas. Local (i.e., regional, county, or city managed) areas are not identified

herein. Project planners should consult with regional or local governments to ensure that all environmental approvals are obtained prior to conducting sediment management activities in locally-managed areas.

5.3.1 Conservation Areas, Refuges, and Reserves

Several State Marine Conservation Areas and Reserves are located in the San Luis Obispo County. In addition, the northern portion of the County is located in the MBNMS. Many of these managed areas are home to special status species, such as marine mammals and ESA-protected fishes. They also harbor important habitats protected by other state and federal environmental statutes. Marine Protected Areas (MPAs) are similar to state parks; they help protect and restore marine organisms. In some conservation areas and reserves, many activities are restricted. Other areas may allow some recreation or fishing. In the most restrictive protected areas, the taking of any species is prohibited.

Table 14. San Luis Obispo County Conservation Areas, Refuges, and Reserves.

Conservation Areas, Refuges, and Reserves	Figure	Notes
Monterey Bay National Marine Sanctuary	15	Northern portion of Morro Bay Littoral Cell is in the MBNMS. All sediment management activities conducted in the sanctuary will require approval from the MBNMS.
Piedras Blancas SMCA	15	Recreational and commercial take of salmon and albacore.
Piedras Blancas SMR	15	Take of all living marine resources is prohibited.
Cambria SMCA	15	Recreational take of living marine resources.
White Rock (Cambria) SMCA	16	Commercial take of giant kelp and bull kelp.
Point Buchon SMCA	17	Recreational and commercial take of salmon and albacore.
Point Buchon SMR	17	Take of all living marine resources is prohibited.
Morro Bay SMRMA	18	Recreational take of finfish, commercial oyster aquaculture, and storing finfish taken outside of the SMRMA for bait purposes.
Morro Bay SMR	18	Take of all living marine resources is prohibited.
Morro Dunes Natural Reserve	18	Morro Bay kangaroo rat critical habitat; Morro shoulderband snail critical habitat; California least tern habitat; Western snowy plover habitat; Globose dune beetle habitat; Morro blue butterfly habitat; Morro shoulderband snail habitat;
Oceano Dunes Natural Preserve	19,9	La Graciosa thistle critical habitat; California least tern habitat; Western snowy plover habitat;
Guadalupe Nipomo Dunes National Wildlife Refuge	19	California least tern habitat; Western snowy plover habitat; California tiger salamander habitat; , California red-legged frog habitat;

SMCA - State Marine Conservation Areas
SMR - State Marine Reserves
SMRMA - State Marine Recreational Management Area

5.3.2 San Luis Obispo County State Parks and State Beaches

The San Luis Obispo County littoral cells are home to several state beaches and parks (Table 15), and the California Department of Parks and Recreation has jurisdiction over activities conducted within them.

Table 15. San Luis Obispo County State Parks and Beaches.

State Park or Beach	Figure	Notes
Ragged Point Beach – San Carpoforo Creek	15	Steelhead Critical Habitat Black Abalone Critical Habitat
Arroyo de la Cruz Beach	15	Steelhead Critical Habitat Black Abalone Critical Habitat
Point Piedras Blancas	15	Black Abalone Critical Habitat Elephant seal rockery
W.R. Hearst Memorial State Beach	15	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat
Little Pico Creek	15	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat
Pico Creek	15	Steelhead Critical Habitat Black Abalone Critical Habitat
San Simeon State Park	15	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat
Moonstone Beach	15	Steelhead Critical Habitat Black Abalone Critical Habitat
Estero Bluffs State Park	17	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat Western Snowy Plover Critical Habitat
Cayucos State Beach	17, 20	Steelhead Critical Habitat Black Abalone Critical Habitat
Toro Creek	17	Steelhead Critical Habitat
Morro Strand State Beach	17	Steelhead Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat
Morro Bay State Park, Morro Dunes Natural Reserve	17, 18	Morro Bay Kangaroo Rat Critical Habitat; Morro Shoulderband Snail Critical Habitat Tidewater Goby Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat
Montaña de Oro State Park	17	Steelhead Critical Habitat Black Abalone Critical Habitat Morro Shoulderband Snail Critical Habitat
Point San Luis to Olde Port Beach	19	Black Abalone Critical Habitat
Avila Beach	19, 21	Steelhead Critical Habitat Black Abalone Critical Habitat
Pirate's Cove	19	Black Abalone Critical Habitat
South Palisades Park	19, 21	Black Abalone Critical Habitat
Shell Beach	19, 21	Black Abalone Critical Habitat
Pismo State Beach	19, 22	Steelhead Critical Habitat Black Abalone Critical Habitat La Graciosa Thistle Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat

Oceano Dunes State Vehicular Recreation Area	6, 9	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat La Graciosa Thistle Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat
Oceano Dunes Natural Preserve	6, 9	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat La Graciosa Thistle Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat
Guadalupe Nipomo Dunes National Wildlife Refuge	6	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat La Graciosa Thistle Critical Habitat Western Snowy Plover Habitat California Least Tern Habitat

5.4 Fish and Wildlife of the San Luis Obispo County Littoral Cells

The Morro Bay and Santa Maria Littoral Cells are located in one of the most diverse biological areas along the California coast. The coastal waters are known for their biological richness and unique habitats, and most of the coastline is rugged and natural. The waters of the littoral cells are used by more than 30 species of marine mammals, many of which are resident; 130 species of seabirds; more than 500 species of fish; and countless invertebrates.

Common seabirds present in the littoral cells include loons (common, Pacific, red-throated, and yellow-billed); grebes (Clark's, western, and others); albatross (black-footed, laysan, and short-tailed); several species of shearwaters; petrels; American white and California brown pelicans; cormorants (Brandt's, double-crested, and pelagic); herons and egrets; rails; coots; plovers; sparrows; and several other birds2 (MBNMS 2014).

Common fish in the littoral cells include grunion; hagfish; various sharks; skates; salmon; eels; Pacific sardine; smelt (surf, whitebait, night); numerous species of rockfish; sablefish; kelp and rock greenlings; lingcod; sculpins; poachers; snailfish; and many other species (Burton and Lea 2013).

5.5 Laws and Regulations Governing Special Status Species

The San Luis Obispo littoral cells and adjacent upland areas provides habitat for several special status species, including federal and state ESA-protected species, marine mammals, California Department of Fish and Wildlife (CDFW) fully protected (FP) species, and Essential Fish Habitat (EFH). Prior to conducting sediment management activities and during the permitting process, project planners will need to consult with the United States Fish and Wildlife

Service (USFWS), National Marine Fishery Service (NMFS), or the CDFW. This section provides a brief overview of the various statues and regulations protecting special status species.

5.5.1 Federal Endangered Species Act

The purpose of the Endangered Species Act (ESA; 16 U.S.C § 1531 et. seq.) is to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the USFWS and NMFS. The USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife such as whales and anadromous fish such as salmon.

Under the ESA, species may be listed as either endangered or threatened. "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range. "Threatened" means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. For the purposes of the ESA, Congress defined species to include subspecies, varieties, and, for vertebrates, distinct population segments.

The ESA makes it unlawful for a person to take a listed animal without a permit. Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." Through regulations, the term "harm" is defined as "an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." Listed plants are not protected from take, although it is illegal to collect or maliciously harm them on federal land. Protection from commercial trade and the effects of Federal actions do apply for plants. In addition, states may have their own laws restricting activity involving listed species.

The San Luis Obispo County littoral cells are home to several special status species. These species include federally threatened (FT), endangered (FE), species of concern (SC), and critical habitat (CH), including: California least tern (*Sterna antillarum browni* [FE, CH]), marbled murrelet (*Brachyramphus marmoratus marmoratus* [FT]), western snowy plover (*Caradrius alexandrines nivosus* [FT, PCH]), South-Central Coast California steelhead (*Oncorhynchus mykiss* [FE, PCH]), tidewater goby (*Eucyclogobius newberryi* [FE]), Southern sea otter (*Enhydra lutris nereis* [FT]), blue whales (FE), fin whales (FE), humpback whales (FE), leatherback turtle (*Dermochelys coriacea* [FE, CH]), Guadalupe fur seal (*Arctocephalus townsendi* [FT]), Western yellow-billed cuckoo (*Coccyzus americanus occidentalis* [FT]), Morro Bay kangaroo rat (*Dipodomys heermanni morroensis* [FE, CH]), black abalone (*Haliotis cracherodii* [FE, CH]), Morro shoulderband snail (*Helminthoglypta walkeriana*, [FE, CH]), Smith's blue butterfly (*Euphilotes enoptes smithi* [FE]), Globose dune beetle (*Coelus globosus* [FSC]), California red-legged frog (*Rana draytonii* [FE, CH]), La Graciosa thistle *Cirsium scariosum* var. *loncholepis*

[FE, CH]), Marsh sandwort (*Arenaria paludicola* [FE]), California seablite (*Suaeda californica* [FE]), Morro manzanita (*Arctostaphylos morroensis* [FT]), Indian Knob mountainbalm (*Eriodictyon altissimum* [FE]), Salt marsh bird's-beak (*Chloropyron maritimum* ssp. *maritimum* [FE]), Pismo clarkia (Clarkia speciosa ssp. immaculate [FE]), Nipomo Mesa lupine (*Lupinus nipomensis* [FE]), Monterey spineflower (*Chorizanthe pungens* var. *pungens* [FT]), and Gambel's water cress (*Nasturtium gambelii* [FE]).

All or portions of the littoral cells are considered critical habitat for some threatened and endangered species. Critical habitat receives protection under the federal ESA through prohibition against destruction or adverse modification. The ESA defines critical habitat as specific areas within the geographical area, occupied by the species at the time of listing, that contain the physical or biological features essential to conservation of the species, and that may require special management considerations or protection. Critical habitat also includes specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. Primary constituent elements of critical habitat include the specific physical and biological features essential to conservation. The federal ESA defines a primary constituent element as a physical or biological feature essential to the conservation of a species for which its designated or proposed critical habitat is based on (50 CFR § 424.12(b)). Primary constituent elements include space for individual and population growth, and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and habitats that are protected from disturbance or are representative of the species historic geographic and ecological distribution.

Prior to conducting sediment management activities, project planners must consult with the USFWS or NMFS or both to ensure that the activity will not jeopardize the continued existence of threatened or endangered species, or adversely modify critical habitat. Those agencies may issue a biological opinion and incidental take statement for sediment management activities. Additionally, reasonable and prudent measures may be included in the biological opinion to further avoid or minimize impacts to listed species.

5.5.2 Marine Mammal Protection Act

Species protected under the Marine Mammal Protection Act (MMPA; 16 U.S.C. § 1361 et.seq.) that use the littoral cells include: pinnipeds such as Pacific harbor seals, northern elephant seals, California sea lions, and northern fur seals; cetaceans may also pass through the area, including blue whales, fin whales, humpback whales, right whales, and sperm whales; and fissipeds such as California sea otters and southern sea otters. Prior to conducting sediment management activities, project planners must consult with the NMFS to ensure that the proposed action will not adversely affect marine mammals. The NMFS may issue an incidental take permit for these activities.

5.5.3 Magnuson-Stevens Fishery Conservation and Management Act Amendments of 1996

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) Amendments of 1996 (16 U.S.C. §1801 et seq) defines Essential Fish Habitats (EFH) to be "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Furthermore, waters are defined as "aquatic areas and their associated physical, chemical, and biological properties that are used by fish," and may include areas historically used by fish. Substrate is defined as "sediment, hard bottom, structures underlying the waters, and associated biological communities"; necessary means "the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem"; and spawning, breeding, feeding or growth to maturity covers the full life cycle of a species.

The MSFCMA also requires NOAA Fisheries to designate a Habitat Area of Particular Concern (HAPC) for each species. HAPCs are subsets of EFH that are rare, particularly susceptible to human-induced degradation, ecologically important, or are located in an environmentally stressed area. The HAPCs are not afforded additional protection beyond that of the EFH; however, federal projects with potential adverse impacts on HAPCs will be given more scrutiny during the consultation process.

The San Luis Obispo County littoral cells are located within an area designated as EFH for three Fishery Management Plans (FMPs): the Pacific Coast Salmon, the Coastal Pelagics, and Pacific Groundfish.

Pacific Salmonid Fishery Management Plan: The current Pacific Salmon FMP provides management protection for the coast-wide aggregate of natural and hatchery salmon species within the EEZ that are fished off the coasts of Washington, Oregon, and California (PFMC 1997, PFMC 2014). These species include Chinook, coho, pink (only in odd-numbered years), and all salmon protected under the ESA. Steelhead are not protected under the FMP. The Pacific Salmon FMP also contains requirements and recommendations for the EFH for the managed salmon species. The EFH includes marine waters within the EEZ, and estuarine and freshwater habitat within Washington, Oregon, California, and Idaho. The action area is within designated EFH for Pacific salmon species. Coho salmon are the only Pacific Salmon FMP salmonid that exists in the littoral cell.

Pacific Groundfish Fishery Management Plan: The Pacific Coast Groundfish FMP provides protection for 87 groundfish species throughout the Pacific Coast of the United States, most of which are found in the littoral cells (NMFS 2008). Because groundfish species are widely dispersed during certain life stages, EFH for groundfish species is correspondingly large. Therefore, EFH for Pacific Coast Groundfish includes: the entire Exclusive Economic Zone (EEZ) and all the waters from MHHW to the upriver extent of saltwater intrusion in river mouths along the coasts of Washington, Oregon, and California. The Pacific Coast Groundfish FMP

describes seven composite units that comprise pacific groundfish EFH: estuarine, rocky shelf, non-rocky shelf, canyon, continental slope/basin, neritic zone, and oceanic zone.

The overall extent of groundfish EFH includes all water and substrate in depths that are less than or equal to 11,500 feet to MHHW or the upriver extent of saltwater intrusion (upstream area and landward where waters have salinities less than 0.5 parts per thousand), seamounts in depths greater than 11,500 feet, and areas designated as HAPCs (for Pacific groundfish, HAPCs include estuary, sea grass, kelp canopy, and rocky habitats).

Coastal Pelagic Fishery Management Plan: The Coastal Pelagic FMP provides protection for commercial pelagic species, including four finfish: Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*); market squid (*Loligo opalescens*); and various species of krill and euphausiids. All of these species are present in the littoral cells.

The EFH for the finfish species and squid is based on a thermal range bordered by the geographical area where these species occur at any life stage. It includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington, offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 50 and 78 degrees Fahrenheit. The EFH for krill extends the length of the West Coast from the shoreline to the 6,000 foot isobath and a depth of 1,300 feet (NMFS 2011).

5.5.4 Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (MBTA; 16 U.S.C. §§703-712) established a federal prohibition to "…pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess…at any time, or in any manner, any migratory bird…or any part, nest, or egg of such bird." (16 U.S.C. 703). The CRSMP area is on the Pacific Flyway. Several migratory birds migrate through the littoral cells, stopping to feed, roost, and even nest. Prior to conducting sediment management activities, project planners should contact the USFWS to discuss migratory birds in the project area and ensure that the project would not adversely affect migratory birds.

5.5.5 California Endangered Species Act

The California Endangered Species Act (CESA) protects all native species of fish, amphibians, reptiles, birds, mammals, invertebrates, and plants - as well their habitats - threatened with extinction or in significant decline. Several species protected under the CESA are also protected under the federal ESA. The CESA makes it unlawful to harm or take (defined in Fish and Game Code section 86) listed species without an incidental take permit or consistency determination with a federal ESA biological opinion and incidental take statement. Furthermore, the CESA requires 'full mitigation' for take of any listed species. Prior to conducting sediment

management activities, project planners should coordinate with the CDFW on potential impacts to state-listed species and obtain the appropriate approvals.

5.5.6 CDFW Fully Protected Species

California provides additional protection for Fully Protected (FP) species under Fish and Game Code sections 3511, 4700, 5050, and 5515. Each of these sections prohibits take or possession at any time of fully protected species. Six fully protected species are present in the littoral cell – the Morro Bay kangaroo rat, California brown pelican, California least tern, southern sea otter, Guadalupe fur seal, and northern elephant seal. The CDFW is not able to issue a CESA incidental take permit or consistency determination if a project will result in the take of a fully protected species. Prior to conducting sediment management activities, project planners should work with the CDFW to ensure that fully protected species are not affected by project activities.

5.5.7 Special Status Species

San Luis Obispo County provides habitat for numerous special status species, including species protected under state and federal ESAs, protected marine mammals, migratory birds, and other state protections, such as fully protected species or species protected under various Fish and Game codes (Figure 31 through Figure 33). This section only identifies those special status species that have the potential to be affected by sediment management activities in San Luis Obispo County. The California Natural Diversity Database (CNDDB) was queried to assist in this assessment and a buffer was added to include only those species observations present within the coastal region of the county. Special status species are summarized in the Environmental Appendix.

Figure 31. Steelhead (Oncorhynchus mykiss). Photo from NMFS 2012.

Figure 32. Black abalone (*Haliotis cracherodii*).

Figure 33. Sea otters (*Enhydra lutris nereis*) in Morro Bay.

5.6 Impact Considerations

Direct, indirect, or cumulative impacts to biological habitats and resources may result from RSM activities. Direct impacts are "caused by the action and occur at the same time and place" (40 Code of Federal Regulations Sec. 1508). Examples of direct impacts include burial or removal of soft bottom, benthic invertebrates during sand placement or dredging/excavation, respectively. Direct impacts also may occur to invertebrates and fish that become entrained with water that is removed or pumped during dredging operations. There also may be the potential for direct impacts to managed species, if present in the construction area.

Generally, sandy beach invertebrate assemblages recover within one year or less, but may take longer if disturbance affects highly diverse communities, long-lived species, repetitive disturbances occur before recovery is complete, or source materials substantially differ from existing sediment (reviewed in CSMW 2012a). Subtidal invertebrate recovery takes one to three years depending on water depth and environmental conditions.

Indirect impacts are "caused by the action and are later in time or farther removed in distance, and may include ..... related effects on water and other natural systems, including ecosystems" (40 Code of Federal Regulations Sec. 1508). Indirect consequences of direct impacts to benthic organisms are reduction in forage for wildlife, the duration of which relates to benthic recovery rates. Waters are indirectly impacted by sediment disturbance or placement, primarily resulting in a temporary decrease in water clarity (turbidity); however, changes to water chemistry also may occur depending on the characteristics of the sediments. Indirect impacts to nearby invertebrates, fish, birds, marine mammals, or vegetation have the potential to occur at distances within a few hundred feet to over one mile from effects such as equipment noise, turbidity, sedimentation (settlement of suspended sediment), or sand transport away from a receiver site because of waves and tides over time.

Direct and most indirect impacts are associated with the construction phase of RSM activities. Impacts of potential concern during the construction phase include:

- Removal or damage to sensitive habitats or resources from equipment operation (dredges, pipelines vehicles, vessels), sand placement, or sand removal
- Disturbance or interference with movement, foraging, and/or reproduction of sensitive species from equipment operation (noise, disturbance)
- Persistent water-quality changes (e.g., turbidity) that interfere with foraging, respiration, recruitment, or reproduction of sensitive species or degrade vegetated habitats
- Potential for the release of contaminants and associated adverse effects on aquatic animals (NRC 1985, 1995)

After sand placement or removal, the primary indirect impact relates to the recovery rate of invertebrates, which represent important forage for fish and birds. Important considerations of recovery rates include the relative change in sediment and habitat quality relative to existing conditions and project timing. Invertebrates seasonally recruit to beaches; therefore, recovery may be promoted by conducting projects outside the spring-summer peak productivity period. Recovery of subtidal invertebrate assemblage may also be promoted by minimizing changes in sediment, hydrodynamics, or water quality within dredged areas.

The primary indirect impact concern of sand migration from the receiver site is the potential to degrade sensitive habitats, if nearby. Impacts of potential concern after construction include:

- Alteration of sediment, hydrodynamics, or habitat quality that delays invertebrate recovery rates
- Turbidity, sedimentation. or sand migration that degrades nearshore reefs or vegetated habitats of particular concern (HAPCs)
- Sand migration that increases the frequency or volume of maintenance dredging or excavation in nearby bays, creeks, or harbors

Cumulative effects are the "impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions ..." (40 Code of Federal Regulations 1508.7). The area of potential effect may occur in the Plan area over time because of repeated effects from an action in the same area, additive effects from multiple impact sources, or a combination of effects taking place slowly over time (Peterson and Bishop 2005).

RSM planning provides an opportunity to increase the regional effectiveness of beneficial use of maintenance dredged materials, opportunistic upland sand sources, and offshore dredging and beach nourishment projects. Because RSM activities usually involve repetitive beach nourishment and dredging in certain areas, the potential for cumulative impacts is an anticipated issue of concern. Avoidance of repetitive disturbance within the same Plan area within the same year is recommended to promote recovery of the invertebrate prey base and minimize cumulative impacts.

Establishing a geospatial database to track projects, sediment quantities, and frequency of implementation would facilitate assessment of potential cumulative impacts on the basis of both geographical (e.g., percentage of planning area affected) and temporal (frequency) scales of disturbance. This information, in combination with monitoring, would support evaluations of Plan performance and possibly future adaptive refinement of implementation to optimize long-term benefits and reduce environmental impacts associated with RSM in San Luis Obispo County.

Impacts of RSM projects would depend on project-specific details (e.g., sediment volume, equipment, methods), site-specific environmental conditions, and construction schedule. Project-specific impact assessments would be conducted as part of the environmental review and permitting process prior to project implementation.

Use of best practice and resource protection guidelines in project design and implementation are recommended to minimize impacts. Construction phase measures may include buffer distances, schedule restrictions (e.g., environmental windows), equipment operational controls, best management practices (BMPs), or monitoring. The Regional Water Quality Control Board (RWQCB) may require monitoring of water quality to meet waste discharge requirements specified as a condition of the 401 water quality certification. Biological monitoring may be required by resource agencies to verify absence of sensitive species from the Plan area during construction, halt or redirect construction if sensitive resources enter the Plan area, ensure construction does not significantly impact sensitive resources, confirm construction remains within designated work areas, or to verify that unexpected impacts do not occur. Depending on the project-specific concerns, monitoring may be focused (e.g., eelgrass, grunion, least tern, snowy plover, Pismo clams) or may assess biological communities of particular interest (e.g., benthic invertebrate community, bird foraging-invertebrate prey interactions, hard-bottom

habitat); biological indicators generally are used to monitor community level responses. Monitoring requirements may vary on a project-specific basis depending on resources within the vicinity of the proposed sediment management project. Impact verification monitoring may be required depending on level of concern or uncertainty associated with potential impacts to sensitive habitats. Monitoring requirements would be determined during environmental review and permitting. Additionally, monitoring may provide opportunities to gather additional information relative to sand placement techniques or minimization measures that would support adaptive management decision making to improve the environmental effectiveness of plan implementation over time.

Table 16 summarizes the biological constraints for the San Luis Obispo County beaches of interest (Table 17), and Table 18 summarizes the environmental constraint periods for relevant managed and sensitive species associated with sand placement on beaches. Construction work windows are relatively unconstrained during the fall and winter except in areas with wintering concentrations of snowy plover. Construction work windows in the spring and summer are constrained by California grunion if suitable beach habitat to support spawning is present. Additional constraints also may apply if sites are located nearby nesting sites of California least tern or snowy plover. Snowy plover critical habitat is a constraint regardless of season.

Table 16. Biological considerations and constraints for San Luis Obispo County beaches of interest.

Location	Habitat Type	Constraints
Cayucos State Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Steelhead Critical Habitat Black Abalone Critical Habitat
Cayucos Bluffs Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Steelhead Critical Habitat Black Abalone Critical Habitat
Avila Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Steelhead Critical Habitat Black Abalone Critical Habitat
Palisades Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Black Abalone Critical Habitat
Spyglass Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Black Abalone Critical Habitat
Dinosaur Caves Beach	Sandy Beach	Adjacent Rocky Intertidal and Kelp Forest Habitat Black Abalone Critical Habitat
Pismo Beach	Sandy Beach	Steelhead Critical Habitat Black Abalone Critical Habitat Tidewater Goby Critical Habitat
Pismo Beach Nearshore	Sandy Subtidal	Steelhead Critical Habitat Black Abalone Critical Habitat
Oceano Beach	Sandy Beach	Steelhead Critical Habitat Black Abalone Critical Habitat
Oceano Beach Nearshore	Sandy Subtidal	Steelhead Critical Habitat Black Abalone Critical Habitat

Table 17. Beaches of interest in San Luis Obispo County

Location	Habitat Type
Cayucos State Beach	Sandy Beach
Cayucos Bluffs Beach	Sandy Beach
Avila Beach	Sandy Beach
Palisades Beach	Sandy Beach
Spyglass Beach	Sandy Beach
Dinosaur Caves Beach	Sandy Beach
Pismo Beach	Sandy Beach
Pismo Beach Nearshore	Sandy Subtidal
Oceano Beach	Sandy Beach
Oceano Beach Nearshore	Sandy Subtidal

Table 18. Summary of Environmental Constraint Periods by Species.

Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Grunion												
Least Tern breeding/nesting												
Snowy Plover - breeding/nesting												
Snowy Plover - wintering												

Constraint periods may differ in their specification among historical permits or documents; for example, the constraint period for least tern is generally identified as April 15 to September 15 by USACE, although it is listed as April 1 to August 30 in Regional General Permit (RGP) 67 (USACE 2006, 2013). The snowy plover breeding season constraint period may be identified as March 1 to September 15 or September 30 (RGP 67). Generally, the grunion constraint period extends from March 1 through August 31. Verification of constraint periods and work windows for coastal projects conducted in San Luis Obispo County should be verified during project permitting, as applicable.

For projects scheduled during the spring and summer construction window (between March 1 and September 30), pre-construction survey assessment and coordination with resource and regulatory agencies may be necessary to assess habitat suitability for grunion spawning and impact considerations for sensitive species (e.g., least terns, snowy plovers), as applicable, depending on environmental conditions and proximity to sensitive resources. Potential impact considerations include project schedule, interference with spawning, burial of eggs, sediment compatibility, constructed beach slope, and turbidity. Beach nourishment has the potential to enhance spawning habitat in erosive beach areas.

RSM projects would require consultation between the US Army Corps of Engineers (USACE) and USFWS or NMFS under Section 7 of the Endangered Species Act if activities have the potential to affect least tern or snowy plover during the breeding season, critical habitat of snowy plover, or interfere with the movement or behavior of other sensitive wildlife (e.g., endangered sea turtles). Coordination with the USFWS should occur for projects located within two miles of least tern breeding colonies. Mitigation measures (e.g., monitoring, protective measures) may be necessary to conduct beach nourishment during constraint periods depending on project- and site-specific conditions.

Pre-project coordination with resource and regulatory agencies also may be necessary during the fall-winter construction window (October 1-February 28) if there would be the potential to affect snowy plover critical habitat or wintering populations. Coordination should include review of proximity to critical habitat and recent winter survey data, as available, and identification of whether additional mitigation measures (e.g., construction monitoring, delineate access and work areas) may be warranted.

Proximity of RSM activities to sensitive resources is an important consideration relative to the need to implement mitigation measures to avoid or minimize impacts. The RGP 67 specified that opportunistic sand placement would be restricted unless coordinated in advance with USACE and USFWS if within 1,500 feet of snowy plover nest sites or 3,000 feet of least tern nest sites (USACE 2006). A minimum distance of 300 feet has been used to minimize impacts of dredging at major roost sites of brown pelican.

Proximity is an important consideration when conducting RSM projects in the vicinity of hard bottom or vegetated habitats. The potential for turbidity, sedimentation, or sand movement after placement to result in sanding-in of sensitive reefs or reduction in surfgrass or kelp are important impact considerations. Kelp plants also are vulnerable to vessel impacts (propellers, anchoring) resulting in frond entanglement or dislodgement of holdfasts. Light reduction does not impact adult plants with surface canopies, but can reduce establishment of early life stages and growth of juvenile plants. Therefore, turbidity from sediment management is a potential concern if substantial and/or prolonged. Dredging, discharge, or nourishment are of concern in proximity to eelgrass. Burial, turbidity, or removal may result in habitat reduction or loss.

Several factors may contribute to the potential to affect sensitive habitats in the vicinity of RSM activities involving dredging or discharges:

- Distance between project activities and sensitive habitat
- Sand volume and duration of activity
- Oceanographic conditions (e.g., current magnitude and direction) during and after project implementation
- Physical characteristics of the hard-bottom habitat (e.g., predominant reef heights, spatial extent of hard-bottom area, resource development, natural sand flow dynamics through the hard-bottom area)
- Occurrence of barriers (e.g., groin, jetty) that may contribute to sand accumulation (CSMW 2012b)

The locations of sensitive biological resources that have the potential to be affected by sediment-management activities generally are mapped and described as part of the environmental review process. According to the Southern California Eelgrass Mitigation Policy (SCEMP), before and after mapping surveys of eelgrass are required if there is the potential for impact from project construction. Impact verification monitoring may be a permit requirement depending on level of concern or uncertainty associated with potential impacts to other sensitive habitats. Impacts resulting in loss or degradation of HAPC reefs, surfgrass, or kelp bed habitats would require consultation with resource and regulatory agencies to determine appropriate compensatory mitigation to avoid significant impacts. Impacts resulting in loss of HAPC eelgrass habitat would require compensatory mitigation consistent with the SCEMP (NMFS 2011). Eelgrass mitigation requirements differ depending on size of impact and timing of mitigation relative to impact. Generally, an eelgrass mitigation ratio of 1.2 to 1 (i.e., 20 percent

increase in mitigation area relative to impacted area) is required unless the mitigation is performed three years in advance of the impact or the size of the impact is very small.

6. REGULATORY AND POLICY CONSIDERATIONS

6.1 SECTION OVERVIEW

This section describes the regulatory compliance process for implementing CRSMP projects in San Luis Obispo County. It also provides an overview of the roles and responsibilities of federal and state agencies that would be involved in review and permitting of various potential RSM measures.

The information provided here is a general overview of applicable laws, regulations, and agencies rather than a detailed roadmap of the regulatory and permitting process. The CSMW's *Beach Restoration Regulatory Guide* (BRRG) (EIC, 2006) is a recommended resource for planners and sediment managers. It contains more comprehensive and specific information on the permitting process and relevant state and federal regulatory requirements for implementation of beach nourishment projects in California. As part of the *California Coastal Sediment Master Plan* the BRRG was developed to provide an analysis of relevant policies, procedures, and regulations and to assist coastal planners and managers in navigating the regulatory compliance process for beach restoration projects. The BRRG can be found online at: http://dbw.ca.gov/csmw/PDF/BBRG_Final.pdf.

6.2 AN OVERVIEW OF THE REGULATORY COMPLIANCE PROCESS FOR RSM PROJECTS

Although the precise requirements and process would vary based on the specifics of each project, regulatory compliance can generally be broken down into two major components or processes: 1) Environmental Review and 2) Permitting. These processes along with the applicable laws and regulations, roles and responsibilities of various agencies are summarized in this section. The BRRG (EIC, 2006) should be referred to for more guidance on specific requirements and necessary steps in carrying out these environmental review and permitting processes.

6.2.1 Environmental Review Process

Environmental review consists primarily of compliance with the *National Environmental Policy Act* (NEPA) and the *California Environmental Quality Act* (CEQA), but also with several other state and federal laws. Environmental review is typically completed or nearly completed prior to embarking on the permitting process, since the information developed during this phase will be used by permitting agencies in reviewing the project and making permit decisions. Environmental review and permitting should be viewed as part of an iterative process, and coordination between the permit applicant and regulatory agencies should begin early and reoccur often to ensure that the environmental review documentation will provide the information necessary to satisfy the needs of the permitting and review agencies.

Implementation of RSM measures will require preparation of NEPA or CEQA documentation or both. Compliance with CEQA is required for all projects that necessitate approval or financing by the state or local government or participation by state government. NEPA compliance is required by projects that are sponsored by a federal entity. NEPA and CEQA each require preparation of different documents. CEQA documentation would include a *Negative Declaration* (ND), a *Mitigated Negative Declaration* (MND), or an *Environmental Impact Report* (EIR). Acceptable NEPA documentation could consist of an *Environmental Assessment* (EA) with a *Finding of No Significant Impact* (FONSI) or a more comprehensive *Environmental Impact Statement* (EIS). Compliance with CEQA and NEPA each entails undergoing a specific process and series of implementation requirements (e.g., public notification) and steps to ultimately arrive at a determination of potential environmental impacts associated with a proposed project. A NEPA compliance process flowchart is provided in Figure 34 and a CEQA flowchart in Figure 35. For additional information, both the NEPA and CEQA compliance processes are both discussed in detail in the BRRG (EIC, 2006). In certain cases environmental review would consist of compliance with both NEPA and CEQA. Although there are many similarities in the implementation of NEPA and CEQA, there are some key differences that are important to understand (

Table).

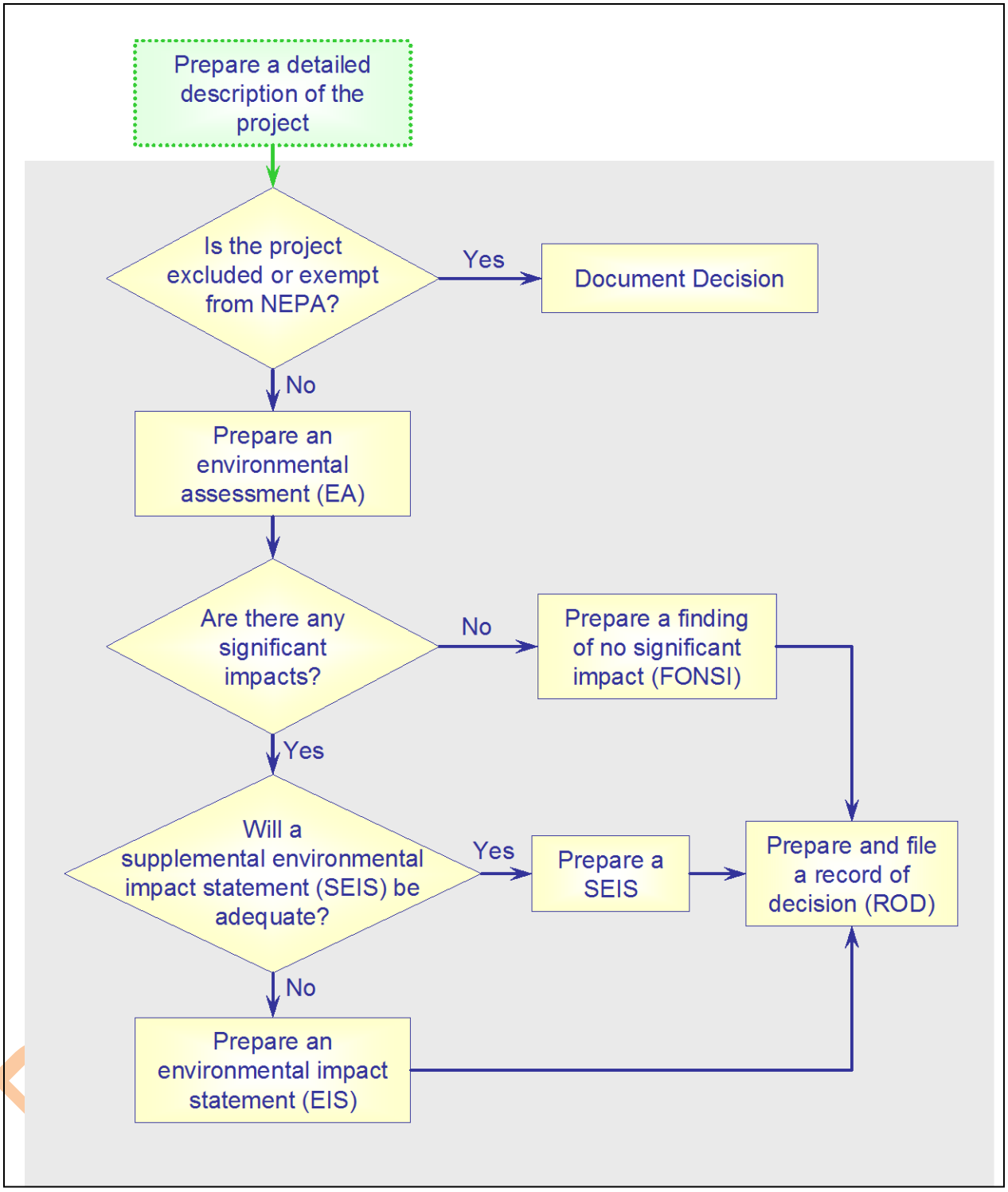
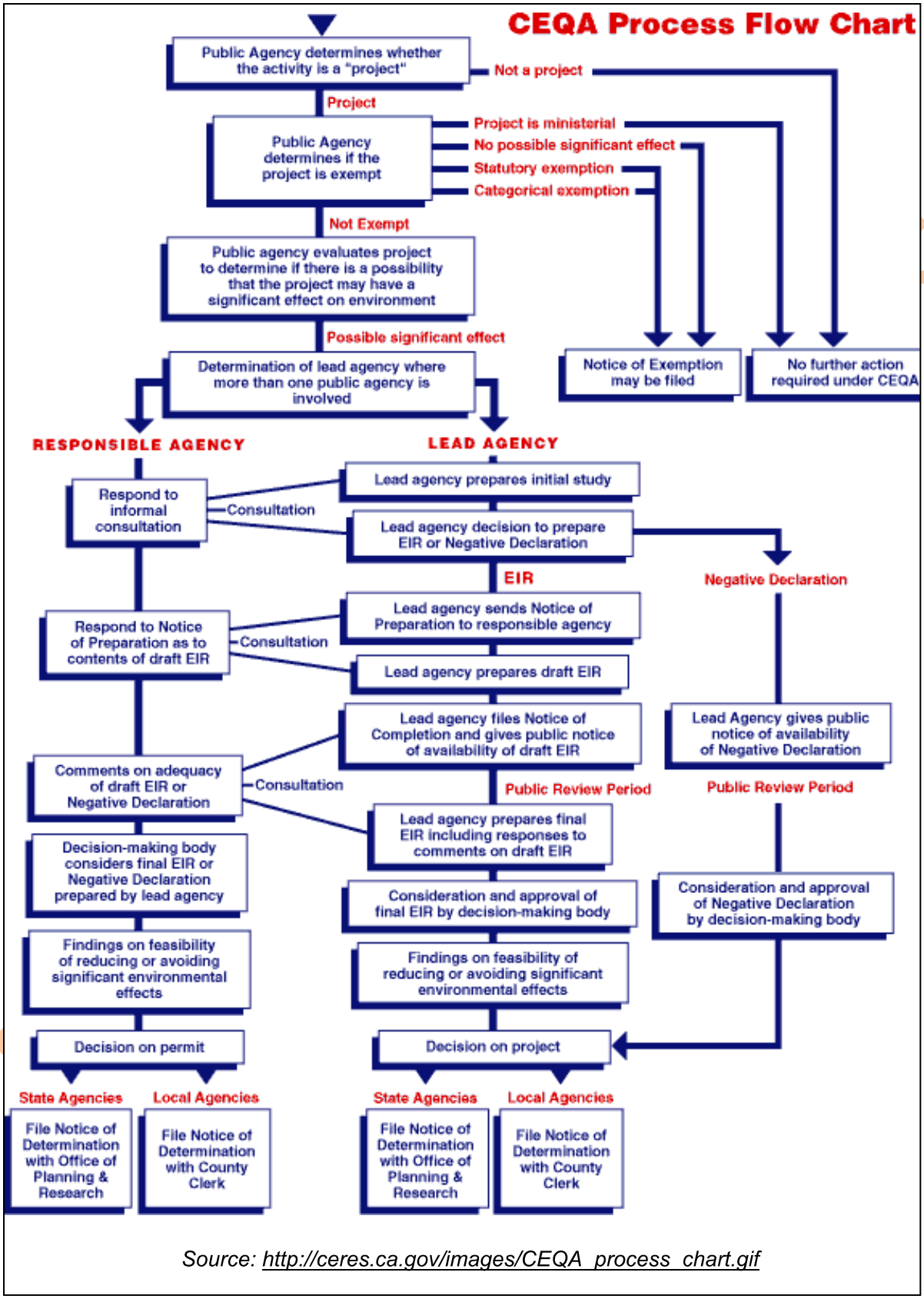


Figure 34. NEPA compliance flowchart



Source: http://ceres.ca.gov/images/CEQA_process_chart.gif

Figure 35. CEQA compliance flowchart

Table 19. Major differences between NEPA and CEQA

NEPA	CEQA
Agencies do not have to mitigate impacts	Agencies must mitigate impacts when feasible
Public noticing is not required for a FONSI (USACE does circulate a public notice to start the EA/Individual Permit process)	Public noticing required for negative declarations
Federal register notification required for draft EIS	Public noticing required for draft EIRs
Federal register notification required for final EIS	Public noticing not required for final EIRs
No time limits for preparation of environmental documents	Permit Streamlining Act applies for publicly-funded projects
No statute of limitation	Some statutes of limitation
ROD must only address why the decision was made, and a ROD is not required for EA/FONSI	ROD (findings) must explain whether each impact has been mitigated and, if not, why
Alternatives must be analyzed to a similar level of detail	Alternatives do not have to be analyzed to a similar level of detail as the proposed project
Environmental impact analyses must include an evaluation of reasonably foreseeable indirect and cumulative impacts	Environmental impact analyses do not have to include speculative impacts
Document must include integration of other federal environmental laws	Document does not have to include integration of other federal environmental laws but should identify relevant state and local ordinances

Source: Beach Restoration Regulatory Guide (EIC, 2006)

6.2.2 Agencies and Local Jurisdictions Involved in Review and Permitting of RSM Measures

This section summarizes relevant federal, state and local agencies and municipalities involved in sediment management activities. Specific roles and responsibilities of these agencies, as they pertain to Coastal RSM projects, are described in more detail in Sections 6.2.3 and 6.3. There are numerous state and federal regulatory agencies that would potentially be involved in reviewing various RSM measures identified in this plan. Which regulations apply and what agencies are responsible for review or approval will vary from project to project.

Federal agencies involved in conducting, reviewing or approving and permitting potential RSM projects identified in this plan include: USACE, the MBNMS, the USGS, and BOEM. The USEPA and USACE are the two main agencies involved in regulating discharges of fill and dredged material. But, numerous other federal agencies are also involved in review of proposed beach nourishment projects and must provide approval before permits can be issued. Any RSM

project proposed within the boundaries of the MBNMS, which adjoins the San Luis Obispo coast from Cambria to the Monterey County border, will require Sanctuary review and approval.

State agencies involved in conducting, reviewing, or approving potential RSM projects recommended in this plan include: the CCC, CSLC, SCC, DPR and DBW. The agencies with primary regulatory responsibility over shoreline protective structures are the CCC and CSLC. The SCC and DBW are both involved with funding shoreline maintenance projects and generation of data, while the DPR is involved as a land manager. Local municipalities and agencies could also be involved in implementing RSM measures as well as permitting and review of projects. The County of San Luis Obispo and SLOCOG are regional entities, while local jurisdictions existing within the boundaries of San Luis Obispo County include the coastal cities, Morro Bay and Port San Luis Harbor Districts. Several additional local agencies, including special districts and other relevant entities. may be involved as well.

6.2.3 Relevant Laws and Regulations

Depending on the type of project being proposed, the location of the affected area, and the scale of the project, there is a wide range of state, federal and local laws and regulations that could apply to the implementation of RSM projects, such as beach nourishment or sand-retention structures.

The primary federal laws that shoreline preservation projects must comply with () are the *Clean Water Act*, *National Environmental Policy Act*, *Coastal Zone Management Act*, and *Rivers and Harbors Act*. The primary state laws and regulations include the *California Environmental Quality Act*, the *California Coastal Act* (CCA), the *California Endangered Species Act*, the *California Ocean Plan*, *California Department of Fish and Wildlife Code*, *California Public Resources Code*, and the *Porter-Cologne Water Quality Control Act* (PCWQCA).

Table 20. Relevant regulations affecting beach restoration projects

Policy/Regulation	Requirement	Permitting/Approval Agency
	Federal	
NEPA	Compliance	Lead Agency
Coastal Zone Management Act	Coastal Consistency Determination (CCD)	CCC
Rivers and Harbors Act	Section 10 Permit	USACE
Clean Air Act	Title V Operating Permit	CARB
Clean Water Act	Section 401 Certification or Waiver	RWQCBs
Clean Water Act	Section 402 NPDES Permit	RWQCBs
Clean Water Act	Section 404 Permit	USACE
Endangered Species Act*	Section 7 Consultation	USFWS or MNFS
National Historic Preservation Act*	Section 106 Approval	State Historic Preservation Officer
Fish and Wildlife Coordination Act*	Coordination Act Report (CAR)	USACE

Magnuson-Stevens Fishery Conservation & Management Act*	Assessment of Impacts to Essential Fish Habitat	NMFS
Outer Continental Shelf Lands Act	Lease Agreement for Utilization of Outer Continental Shelf Sand	BOEM
State		
California Environmental Quality Act	Compliance	Lead Agency
California Coastal Act	Coastal Development Permit (CDP)	CCC
Porter-Cologne Water Quality Control Act	Compliance Permits under CWA Sections 401, 402, and 404	SWRCB+, RWQCB
California State Lands Public Resources Code	Lease Agreement for Utilization of Sovereign Lands	CSLC
California Public Resources Code Section 1600	Streambed Alteration Agreement	CDFW
California Endangered Species Act	Section 2081(b) Incidental Take Permit (State) Section 2081.1 Consistency Determination (State and Federal)	CDFW
Water Quality Control Plans California Ocean Plan	Consistency Compliance	RWQCBs +
Clean Air Act	Title V Operating Permit	APCDs and AQMDs

* Review and compliance is usually triggered through the initial Clean Water Act Section 404 permitting process by the USACE.+ The SWRCB has lead responsibility when a project involves jurisdiction by more than one RWQCB.

6.3 Federal Agencies Involved in Permitting and Review of RSM Projects

6.3.1 Monterey Bay National Marine Sanctuary

A detailed description of the Monterey Bay National Marine Sanctuary (MBNMS) and its potential role in reviewing and permitting RSM projects is provided here because it has permitting authority over RSM projects implemented within its boundaries, and because that agency was not included in the BRRG regulatory analysis. Designated in 1992, the MBNMS is a federally protected marine area offshore of California's central coast. Stretching from Marin County to Cambria, it encompasses a shoreline length of 276 miles and 4,601 square nautical miles of ocean, extending an average distance of 30 miles offshore.

The mission of the MBNMS, to understand and protect the ecosystem and cultural resources of central California, is carried out through resource protection, research, education, and public use. As such, it addresses a wide range of resource protection issues within its boundaries, and works to reduce or prevent detrimental human impacts on sanctuary resources through collaborative partner efforts, regulations and permits, emergency response, enforcement and education.

The MBNMS was designated in accordance with the *National Marine Sanctuaries Act* (NMSA) and is managed under the authority of the Act. Under the NMSA, the MBNMS has the ability to grant permits for prohibited activities and enforce its regulations, provided that the activities meet certain criteria such as having, at most, short-term and negligible adverse effects on sanctuary resources and qualities (15 CFR Section 922.133). The primary regulations governing management of the MBNMS are described in the U.S. Code of Federal Regulations, Title 15, Part 922.

The MBNMS enforces thirteen federal regulatory prohibitions designed to preserve and protect the natural and cultural resources and qualities of the ocean and estuarine areas within its boundaries. Depending upon the nature of the project, there are six of these prohibitions that could pertain to potential RSM measures, and thus trigger the need for MBNMS review and permitting. These are summarized below:

1. Drilling into, dredging, or otherwise altering the submerged lands of the sanctuary; or constructing, placing, or abandoning any structure, material, or other matter on or in the submerged lands of the sanctuary (with the exception of several activities, such as boat anchoring and harbor maintenance projects).
2. Discharging or depositing, from within or into the sanctuary, any material or other matter (with the exception of several activities, such as dredged material disposal at designated sites).
3. Discharging or depositing, from beyond the boundary of the sanctuary, any material or other matter that subsequently enters the sanctuary and injures a sanctuary resource or quality (with the exception of several activities unlikely to be applicable to the measures evaluated in this Plan).
4. Taking (disturbing or injuring) any marine mammal, sea turtle, or bird within or above the sanctuary, except as authorized by the MMPA, ESA, or MBTA (regardless of intent).
5. Possessing, moving, removing or injuring a sanctuary historical resource, or attempting such actions.
6. Introducing or otherwise releasing from within or into the sanctuary an introduced species (with the exception of striped bass and some shellfish species approved for aquaculture).

Authorizations may be issued under special circumstances for activities otherwise prohibited by MBNMS regulations if: an activity has been authorized by a valid lease, permit, license, approval or other authorization issued after the effective date of MBNMS designation by any federal, state, or local authority; the Superintendent finds that the activity will not harm sanctuary resources and qualities, and; the applicant complies with all applicable regulations and any specific conditions or terms specified by the Superintendent. An authorization may be issued in conjunction with a valid lease, permit, license, approval or other authorization issued by any federal, state, or local authority of competent jurisdiction. In cases where projects require a CCC

CDP (or another relevant permit issued by a state or federal agency), MBNMS staff could review and potentially authorize that permit.

Regional sediment management or coastal protection measures that would require MBNMS review and approval include any proposed seawall or revetment structure placed below the mean high tide line; beach nourishment project where sediment is placed within MBNMS boundaries, or where sediment subsequently enters the MBNMS and causes negative impacts; any project dredging sand from elsewhere; or any project that involves placement of a structure or equipment on or into the submerged lands of the sanctuary (i.e. submerged breakwaters, perched beaches, groins, emergent breakwaters, and possible seawalls or revetments).

In addition to MBNMS's permitting and regulatory authority over certain RSM projects, the sanctuary participates in a variety of collaborative planning and adaptive management initiatives to address shoreline protection issues through non-regulatory means. The MBNMS Coastal Armoring Action Plan, for example, has several activities that relate to beach nourishment, opportunistic use of dredged material, and identifying alternatives to coastal armoring structures:

> *Based on the scientific and needs assessment, MBNMS will pursue a pilot program to investigate environmentally sound alternatives to coastal armoring, and develop and implement monitoring protocols for the program. Alternatives will include but not be limited to: preventative measures, planned retreat, beach nourishment, and structural responses such as groins or breakwaters.*
>
> *MBNMS will convene interagency working groups to identify and help design sub-region specific design alternatives for identified coastal erosion responses*

Such considerations will include:

> *A. Identifying the suite of preventative measures such as restricting activities that contribute to erosion, predevelopment conditioning of projects and the necessary legal measures or relocation of structures such as road realignment or development demolition, or enhanced vegetation of exposed, erosion prone areas.*
>
> *B. Identifying hard structures that may preempt erosion or help retain sand on beaches. Types of structures may include groins (narrow wooden or concrete constructions that extend from a shore into the sea to protect a beach from erosion), offshore seawalls, breakwater, or submerged structures such as artificial reefs that dissipate wave energy prior to reaching the shoreline. All hard structures would alter the seabed and therefore trigger review by MBNMS as a prohibited activity.*
>
> *C. Identifying appropriate sources of beach quality material and one or more locations for one or more pilot demonstration projects that might receive an MBNMS scientific research permit (and other necessary agency permits) to test and develop appropriate sand supply and beach nourishment program options. MBNMS will develop a coordinating mechanism with the California Coastal Sediment Management Workgroup to promote the exchange of information and ideas. If appropriate sources of sand and potentially beneficial nourishment sites can be identified, the pilot study or studies would develop specific research objectives and study*

methodologies. Criteria for "success" will also be developed. The criteria could include minimal environmental impacts, recreational access, shoreline protection and habitat benefits, the potential for using maintained nourishment to avoid or mitigate for shoreline armoring, and other identifiable overall benefits to MBNMS resources.

At the conclusion of this/these demonstration pilot project(s), the agency working group will evaluate the desirability of, and necessary steps for, continuing such a program involving beach nourishment within MBNMS boundaries. If the sand supply project is to continue, this evaluation will also examine whether revision of MBNMS regulations may be warranted, if a beneficial program might continue via MBNMS permit or authorization in concert with other regulatory agencies.

The MBNMS Harbors and Dredge Disposal Action Plan also includes language that is relevant to this RSM Plan*:*

MBNMS will work with partners to examine the potential beneficial uses for dredged material. Recognizing that littoral sand is a MBNMS resource for various habitat, recreation, access and shoreline protection reasons, MBNMS and other agencies should identify if, when and where beach nourishment is appropriate. As discussed in the Coastal Armoring Action Plan, MBNMS may identify the criteria and data needed to make that determination, including an evaluation of sand transport and science needs and pursuit of a comprehensive research strategy. In addition, MBNMS will work with partners to assess individual and cumulative impacts to sand transport and shoreline dynamics due to existing harbors and artificial groins within the MBNMS. Studies should estimate the quantity of sand and sand-generating beach material that is trapped by such structures and assess means to bypass such material and replicate natural processes to the degree feasible. If investigations indicate that employment of additional beach nourishment sites using clean dredged harbor material would be possible and appropriate, MBNMS may examine whether revision of MBNMS regulations may be warranted; or if a beneficial program might occur via MBNMS permit or authorization in concert with other agencies.

6.3.2 U.S. Army Corps of Engineers

The USACE has regulatory authority over activities involving waters of the U.S. pursuant to *Section 404 of the Clean Water Act* and *Section 10 of the Rivers and Harbor Act.* This includes the regulation of any development or structure that may cause obstructions to U.S. navigable waters, or placement of fill or dredged material (which is defined generally to include any structure that is built). Under Section 404 there are two types of applicable permits that are required: for larger-scale projects with the potential to cause significant impacts, an individual permit is typically required; for activities with minimal potential environmental impacts a general permit is usually required.

The USACE is the chief decision-making agency for federal beach nourishment projects. For USACE to approve a project, the proponent must demonstrate that the proposed project is the "least environmentally damaging practicable alternative." Additionally, under Section 404

permitting, either an *Environmental Assessment* (EA) or an *Environmental Impact Statement* (EIS) is required for beach nourishment projects. The USACE beneficial use-related regulations are located at 33CFR 320-330 and 33 CFR 335-338. For more information on USACE policies, procedures, and regulations refer to the *CSMW's Beach Restoration Regulatory Guide* (EIC, 2006).

6.3.3 National Marine Fisheries Service

The NMFS is the federal agency responsible for managing, protecting, and conserving living marine resources and their habitat throughout the *Exclusive Economic Zone* (typically, waters between 3 and 200 miles offshore). It becomes involved with projects by the way of providing consultation to USACE pursuant to Sections 7 and 10 of the ESA, which governs potential impacts of various activities to species and habitats that are either federally listed or proposed for listing. The NMFS would also review some project proposals for their potential impacts to EFH under the MSFMCA. Pursuant to the MMPA, NMFS is also responsible for protection of most marine mammal species found in the San Luis Obispo County coastal region, with the exception of the southern sea otter (*Enhydra lutris)*, which is under the jurisdiction of the USFWS. With respect to the implementation of potential RSM and coastal protection measures, the main activities that require NMFS review would be impacts on subsurface hard substrate through construction or discharge of materials, such as through beach nourishment projects.

6.3.4 U.S. Coast Guard

The USCG is charged with ensuring safety and security along the U.S. coastline with respect to navigation, management of waterways, and protection of natural resources. The USCG typically is involved with reviewing proposals for structures to be located underwater to ensure that they do not interfere with navigation or present other hazards. Potential USCG involvement with shoreline restoration and protection projects would be through consultation with USACE, as required under Section 404 of the *Clean Water Act* and Section 10 of the Rivers and Harbors Act.

6.3.5 U.S. Fish and Wildlife Service

Similar to NMFS, the USFWS plays a consultative role under Sections 7 and 10 of the ESA, as well as the MMPA. Pursuant to the ESA, the lead agency responsible for environmental review of a proposed project is required to determine whether or not any species listed as either threatened or endangered under the ESA are present in the study area and to determine whether the project will cause any potentially significant impacts on that species.

The USFWS and NMFS both are guided by the same set of regulations under the ESA; however each agency is exclusively responsible for different listed species. The USFWS has jurisdiction over terrestrial animals and sea otters, whereas NMFS is responsible for the remaining listed marine animals and all other marine mammals. If the lead agency responsible for the project were a federal agency, then a Section 7 consultation would occur. Otherwise the

project proponent would need to complete a *Habitat Conservation Plan* (HCP) and submit it to the USFWS for review and approval.

6.3.6 Bureau of Ocean Energy Management

The primary responsibility of BOEM is to regulate mineral exploration and development on the outer continental shelf pursuant to the Outer Continental Shelf (OCS) Lands Act (43 U.S.C. 1331, et. seq.). The BOEM would be involved in beach nourishment projects where the source of sand is located in federal waters on the OCS. State and local governments and other federal agencies negotiate directly with BOEM when OCS sand is needed for projects, such as beach nourishment, that benefit the public.

6.4 State Agencies Involved in Permitting and Review of RSM Projects

6.4.1 California Coastal Commission

The CCC, in collaboration with local counties and cities, is the primary state agency responsible for planning and regulating the use of land and water within California's Coastal Zone, in accordance with the specific policies of the CCA and consistent with the CZMA.

Any proposed RSM projects located within the coastal zone must be reviewed for consistency with the CCA and would require a *Coastal Development Permit*, which involves stringent review of the project by CCC staff. In addition to development within the state's coastal zone, the CCC also has jurisdiction over projects requiring federal permits or approval in federal waters, through CCD approvals.

The CCC was established to assist local governments in implementing local coastal planning and regulatory powers through adoption of Local Coastal Programs (LCPs). An LCP consists of one or more Land Use Plans (LUP) with goals and regulatory policies as well as a set of Implementing Ordinances. The CCA requires local jurisdictions to prepare and submit an LCP; once the CCC approves the LCP then that local jurisdiction has coastal permitting authority. The CCC, however, holds permitting authority over Sovereign Lands, which are submerged lands seaward of the MHT line and those not in within an approved LCP area.

Any projects located on sovereign lands below the MHT line are within CCC appeal jurisdiction (as are lands between the ocean and the first public road). Therefore in many cases, two permits may be necessary for a given RSM measure – one from the local jurisdiction with a certified LCP and one from the CCC.

All construction within the coastal zone requires CCC approval pursuant to CCA *Section 30106*, which regulates coastal development. The definition of development in the CCA is very broad and would encompass many potential coastal protection and restoration measures

including beach nourishment, beach dewatering devices, submerged breakwaters, perched beaches, seawalls or revetments, groins, and emergent breakwaters.

The CCC is also mandated to protect views as well as to maintain public access and enhance recreational opportunities. Consequently, projects that have potentially significant visual impacts (e.g. groins or emergent breakwaters), or public safety or access issues would be reviewed subject to relevant policies of the CCA.

6.4.2 California State Lands Commission

The CSLC was established in 1938 with authority detailed in Division 6 of the California Public Resources Code. It manages nearly 4 million acres of Sovereign Lands underlying California's navigable and tidal waterways, which include over 120 rivers, streams, and sloughs; tidal navigable bays and lagoons; and submerged lands along the entire coastline of the state between the MHT line and three nautical miles offshore.

Any proposed project with infrastructure that would encroach onto CSLC lands, such as a coastal protective structure, would require a CSLC *Encroachment Permit*. For beach nourishment borrow sites located on CSLC lands, a *mineral extraction* lease may also be required.

6.4.3 Central Coast Regional Water Quality Control Board

It is the responsibility of the RWQCBs to preserve and enhance the quality of the state's waters through the development of Water Quality Control Plans (Basin Plans) and the issuance of Waste Discharge Requirements (WDRs), which are required by the California Water Code. The WDRs issued by the RWQCBs, are subject to review by the State Water Board, but do not need the State Water Board's approval before becoming effective.

Any projects requiring a *Clean Water Act Section 404* permit from USACE will require *Section 401 Water Quality Certification* by the appropriate RWQCB. Additionally, the RWQCB requires all construction projects with the potential to disturb one or more acres of land to obtain a General Permit for Storm Water Discharges from Construction Activity. The Storm Water Permit requires the development and implementation of a *Storm Water Pollution Prevention Plan* (SWPPP). The SWPPP identifies Best Management Practices (BMPs) for reducing or eliminating pollutants in runoff that discharges into waterways and storm drains.

6.4.4 California Department of Fish and Wildlife

The CDFW maintains the California list of threatened and endangered species. Under the CESA it is illegal to take any species that are listed as endangered and threatened. Take is defined roughly as any activity resulting directly in direct mortality, permanent or temporary loss of occupied habitat that would result in mortality, or disruption in reproduction to one or more

individuals of the species, or causing avoidance of the habitat resulting in the same as above. The CDFW may evaluate a proposed project's potential to negatively affect species listed as either endangered or threatened in the state. In certain cases, an Incidental Take Permit may also be required. The CDFW often becomes involved in proposed projects through reviewing and commenting on EIRs or EISs.

6.4.5 California Department of Parks and Recreation

The CDPR is responsible for the management and protection of natural and cultural resources and facilitating outdoor recreational opportunities within the 270 state park units. State parks and beaches in the San Luis Obispo County coastal region include, from north to south:

- Hearst San Simeon State Historical Monument (Hearst Castle)
- W.R. Hearst Memorial State Beach
- Hearst San Simeon State Park
- Harmony Headlands State Park
- Estero Bluffs State Park
- Cayucos State Beach
- Morro Strand State Beach
- Morro Bay State Park
- Los Osos Oaks State Natural Reserve
- Montaña de Oro State Park
- Pismo State Beach, and
- Oceano Dunes State Vehicular Recreation Area

Any project located on or affecting state parkland would require approval by CDPR in the form of an Encroachment Permit. In addition to the agency's permitting authority, CDPR has several policies regarding coastal erosion and development that are relevant to this RSM Plan. The following excerpt from the Policy on Coastal Erosion from the *CDPR Operations Manual - Chapter 3 - Natural Resources* – (updated September 2004) provides guidance regarding coastal erosion and development within parks:

> *0307.3.2.1 Coastal Development Siting Policy*
>
> *It is the policy of the Department that natural coastal processes (such as wave erosion, beach deposition, dune formation, lagoon formation, and sea cliff retreat) should be allowed to continue without interference. The Department shall not construct permanent new structures and coastal facilities in areas subject to ocean wave erosion, sea cliff retreat, and unstable cliffs. New structures and facilities located in areas known to be subject to ocean wave erosion, sea cliff retreat, or unstable bluffs shall be expendable or movable. Structural protection and re-protection of existing developments is appropriate only when:*
>
> *a. The cost of protection over time is commensurate with the value of the development to be protected, and*
> *b. It can be shown that the protection will not negatively affect the beach or the near-shore environment.*

Where existing developments must be protected in the short run to achieve park management objectives, including high-density visitor use, the Department should use the most natural-appearing method feasible, while minimizing impacts outside the threatened area. Any shoreline manipulation measures proposed to protect cultural resources may be approved only after an analysis of the significance of the cultural resource and the degree to which proposed measures would impact natural resources and processes, so that an informed decision can be made through an assessment of alternatives and long term costs.

6.4.6 Division of Boating and Waterways

The DBW was established in 1957 upon enactment of legislation that established a state boating agency dedicated to all aspects of recreational boating and a special fund (Harbors and Watercraft Revolving Fund) to fund the division's activities. The DBW is responsible for planning, developing, and improving facilities on state-owned and state-managed properties, including those on State Parks and State Water Project properties. It also provides funding so that local agencies can renew deteriorated facilities or develop new public access. In addition, the DBW is heavily involved in furthering environmentally sound boating practices through its clean and green programs. Also, it is involved in research on climate change and wave prediction as they relate to navigation and coastal protection (http://www.dbw.ca.gov/Environmental/).

The DBW is the state agency with responsibility for studying and reporting beach erosion issues in the state, and for developing measures to stabilize the shoreline pursuant to *Article 2.5* of the *Harbors and Navigation Code*. Following passage of the Public *Beach Restoration Act* (Harbors and Navigation Code Section 69.5-69.9), DBW has responsibility for allocating funds for beach restoration projects.

The DBW reviews certain projects that have the potential to present a hazard to boaters, potentially including certain RSM and coastal protection measures evaluated in this plan, such as groins or submerged breakwaters. Although the DBW is not involved in projects from a regulatory standpoint, the agency plays the primary role in funding local projects and providing technical information.

7. ECONOMIC CONSIDERATIONS

7.1 INTRODUCTION

This section provides a socioeconomic analysis of the beaches and beach recreation in San Luis Obispo County. Because many of the beaches are small and have no official attendance records, the collection of basic primary data at these sites was a paramount concern. The analysis confirms that most of the highly attended beaches are in the southern part of the county. Beach tourism, however, is an important part of the coastal economy throughout the county. Further, since the stakeholders asked for an analysis of the two harbors in the county, this section presents estimates of the economic impacts of Morro Bay Harbor and Port San Luis. This section includes:

- A brief overview of San Luis Obispo County's demographics followed by a description of its beaches
- The socio-economic data and analysis prepared for this project
- A discussion of issues facing San Luis Obispo County's beaches in the future.

7.2 DEMOGRAPHICS

Table 21 presents demographic projections prepared for the San Luis Obispo Council of Governments The region is expected to experience a population increase of 21.1 percent between 2010 and 2040 (0.70 percent per year), which is below the projected population growth for California over the same time period (26.5 percent, or 0.88 percent per year).[1] The population growth rates for the coastal cities of Grover Beach, Morro Bay, and Pismo Beach are generally lower than the inland cities, with 30-year growth rates of 11.7 percent, 11.6 percent, and 17.9 percent, respectively. Data on beach-goer demographics were also gathered in the survey described in Section 7.5.

[1] State projections are from the California Department of Finance, Demographic Research Unit: http://www.dof.ca.gov/research/demographic/reports/projections/P-1/.

Table 21. San Luis Obispo County 2040 Regional Growth Forecast

Household Population and Total Population (Low Growth Projections)

Community	Census 2010	2015	2020	2025	2030	2035	2040	Change in Population	Pct Change in Population (2010-2040)	Avg Annual Change in Population
Incorporated Cities										
Arroyo Grande	17,078	17,412	18,032	18,489	19,062	19,640	20,234	3,156	18.5%	0.62%
Atascadero	26,986	27,285	27,734	28,547	29,566	30,594	31,650	4,664	17.3%	0.58%
Grover Beach	12,967	13,142	13,432	13,650	13,925	14,201	14,486	1,519	11.7%	0.39%
Morro Bay	10,073	10,152	10,244	10,450	10,708	10,969	11,237	1,164	11.6%	0.39%
Paso Robles	29,624	30,522	32,137	33,670	35,592	37,533	39,525	9,901	33.4%	1.11%
Pismo Beach	7,642	7,744	7,912	8,140	8,426	8,714	9,010	1,368	17.9%	0.60%
San Luis Obispo	43,937	44,667	45,964	46,602	47,401	48,208	49,037	5,100	11.6%	0.39%
Incorporated Cities Subtotal:	*148,307*	*150,924*	*155,455*	*159,548*	*164,680*	*169,859*	*175,179*	*26,872*	*18.1%*	*0.60%*
Unincorporated County Total:	*104,324*	*107,109*	*112,643*	*117,147*	*112,794*	*128,497*	*134,351*	*30,027*	*28.8%*	*0.96%*
Total Household Population:	*252,631*	*258,033*	*268,098*	*276,695*	*277,474*	*298,356*	*309,530*	*56,899*	*22.5%*	*0.75%*
Group Quarters Population:	17,006	17,006	17,006	17,006	17,006	17,006	17,006	0	0.0%	0.00%
Regional Total:	**269,637**	**275,039**	**285,104**	**293,701**	**294,480**	**315,362**	**326,536**	**56,899**	**21.1%**	**0.70%**

Source: San Luis Obispo County 2040 Regional Growth Forecast, prepared by AECOM for SLOCOG (2011)

Table 22 shows projected population growth rates of five coastal county communities (Avila Beach, Cambria, Cayucos, Los Osos, and Oceano) from 2010 to 2040, which range from 7 percent to nearly 42 percent. After many years of limited growth in Los Osos due to a building moratorium covering a significant portion of the town, a community-wide sewer system is under construction, which may allow for considerable growth in this bayfront community on the southern end of Morro Bay. Most or all growth in these communities would likely result from infill development within the current urban reserve limit boundaries. Overall, the projected population increase of these five coastal communities from 2010 to 2040 is 29 percent, which is higher than the projected growth rate of the region (see Table 21).

Table 22. Population Projections for Coastal County Communities

Coastal County Communities (Low Growth Projections)

Community	Census 2010	2015	2020	2025	2030	2035	2040	Change in Population	Pct Change in Population (2010-2040)	Avg Annual Change in Population
Coastal County Communities										
Avila Beach	1,464	1,484	1,542	1,607	1,724	1,896	1,985	521	35.6%	1.19%
Cambria	6,020	6,032	6,054	6,080	6,200	6,335	6,485	465	7.7%	0.26%
Cayucos	2,541	2,558	2,581	2,604	2,637	2,800	3,005	464	18.3%	0.61%
Los Osos	13,908	13,988	14,502	16,472	17,593	18,607	19,716	5,808	41.8%	1.39%
Oceano	7,108	7,230	7,351	7,504	7,869	8,426	8,848	1,740	24.5%	0.82%
Coastal Communities Total:	*31,041*	*31,292*	*32,030*	*34,267*	*36,023*	*38,064*	*40,039*	*8,998*	*29.0%*	*0.97%*

Source: San Luis Obispo County Planning and Building Department, prepared for SLOCOG (2011)

Figure 36 depicts the types of lodgings used by overnight visitors to the beaches of the county. Approximately 33 percent of these visitors stay in hotels, while another 50 percent are evenly distributed between short-term rentals and camping.

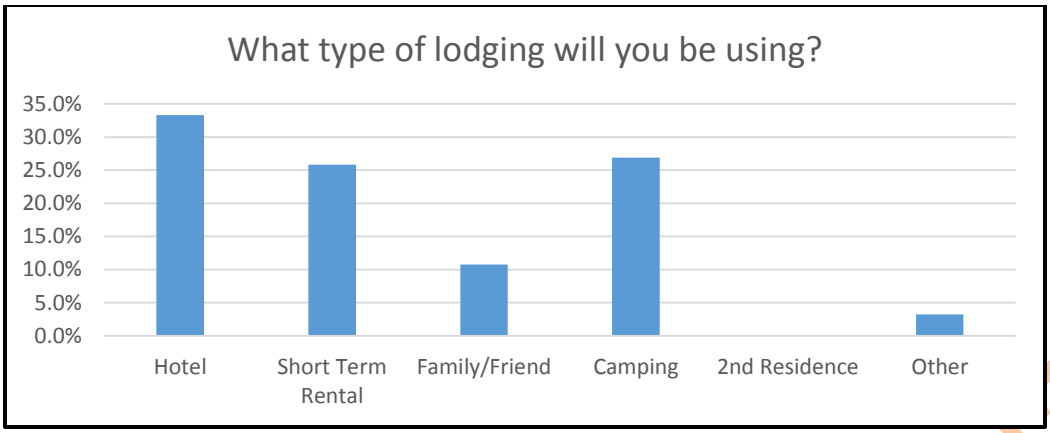


Figure 36. Lodging types for San Luis Obispo County beach-goers.

Figure 37 shows the distribution of annual household incomes for all visitors to beaches in the county. Approximately 70 percent of these households earn between $50,000 and $150,000 per year.

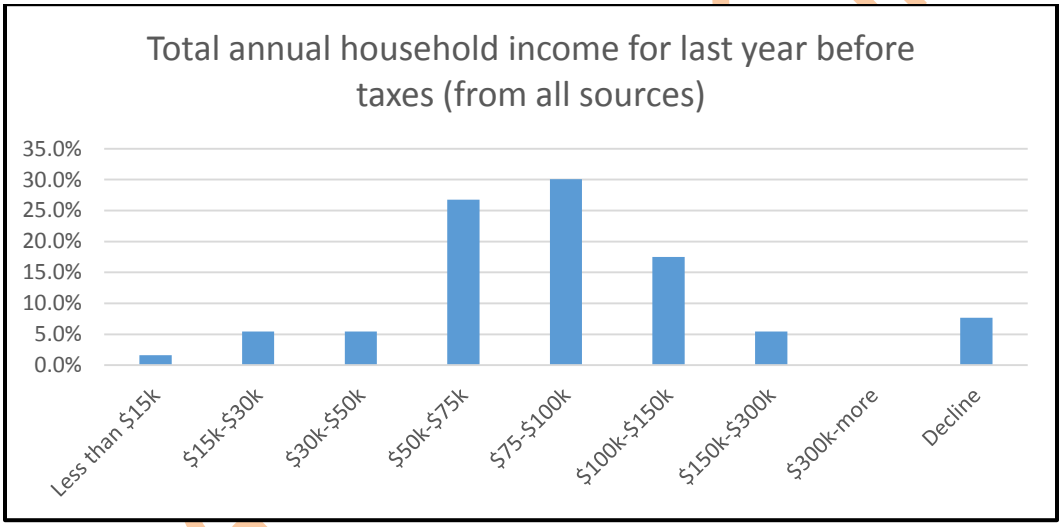


Figure 37. Annual Household Income for San Luis Obispo County beach-goers.

Figure 38 illustrates the age distribution of all visitors to beaches in the county. Visitors between 35 and 44 years old represent the largest demographic (26%), with the percentages gradually tapering down as the age groups get both younger and older.

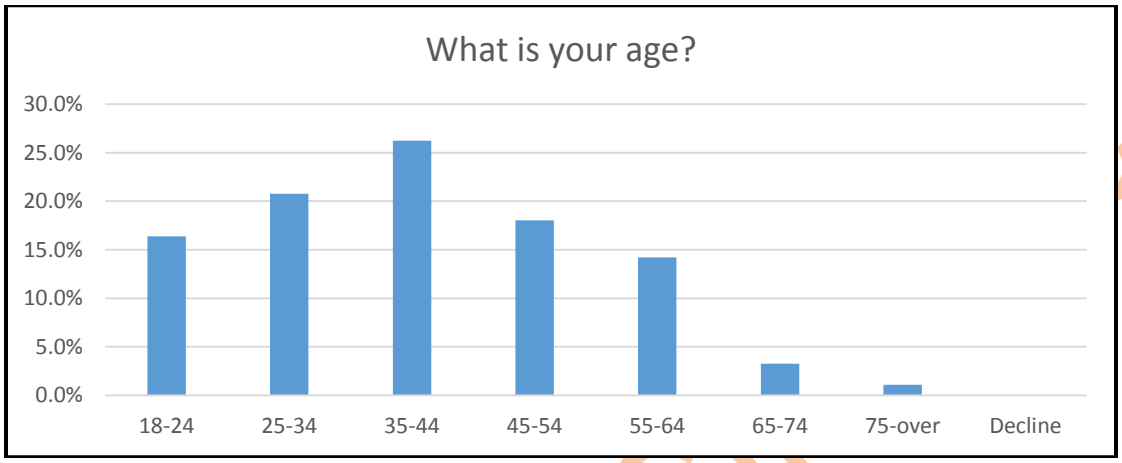


Figure 38. Age of San Luis Obispo County beach-goers.

7.3 Description of Beaches

San Luis Obispo County has a wide variety of beaches. As a general rule, the most popular beaches (e.g., Pismo Beach and Avila Beach) are wider sandy beaches in the southern part of the county. Northward the beaches are narrower and rockier, and the coastal communities tend to be smaller. This section contains a description of the beaches in the county, from south to north.

7.3.1 Guadalupe-Nipomo Dunes/Oso Flaco Lake Natural Area

The southernmost beach in the county, Guadalupe-Nipomo Dunes and Oso Flaco Lake Natural Area is reached by taking a 1.7-mile hike through evergreen and deciduous trees and cutting across a marshy lake, full of wildlife, to a coastal dune chaparral trail to the ocean. This trail borders areas of the Oceano Dunes State Vehicular Recreation Area to the north. Popular with fishermen, this remote beach area provides good beach perch fishing and caters to local residents. The beach provides a nice view of Port San Luis Bay. The beach is, however, unsafe for swimming because the ocean is rough in this area and rip currents are strong. Oso Flaco Lake, which suffers from eutrophication, drains to the ocean here. Located off State Route 1, north of Guadalupe, the access road is surrounded by agriculture fields. There are about 40 parking spaces in the lot with additional parking on the roadsides outside the park gate. There is a $5 entry fee for parking.

7.3.2 Oceano Dunes State Vehicular Recreation Area

The beach front at Oceano Dunes State Vehicular Recreation Area is a long, flat, sandy strip running from the Guadalupe-Nipomo Dunes near Oso Flaco northwards to the Grand Avenue vehicle entry area at Grover Beach. These are some of the largest sand dunes in California, with

many acres and five miles of beach dedicated to off-road vehicle usage. RV/trailer camping is also extremely popular. Parking for beach day-use is available at the Grover Beach entry ramp, and the area has showers, restroom facilities, a restaurant, and a bar. There are a couple hundred parking spaces with renovations to expand currently underway. The Oceano entry ramp also has restrooms and another 25 parking spaces. Parking or driving on the beach costs $5 for day-use and $10 for overnight.

7.3.3 Pismo State Beach

South: This beach is situated between the Grand Avenue vehicle entry ramp (to the south) and the Park Street parking lot (to the north). It includes both Monarch Butterfly Grove and North Beach Campground. Unlike the Oceano Dunes recreation area, vehicles are not allowed on the main beach north of the Grand Avenue entry ramp. Both the Grover and Park Street areas have a boardwalk, restrooms, and outdoor showers. This section of Pismo Beach receives far less tourism activity than both the pier area to the north and the recreation area to the south. The beach front is flat and sandy, making it well-suited to walking and collecting sand dollars. This area is also the beginning of a mile-long, wooden coastal boardwalk trail that runs along the backside of the dunes as well as a small golf course. At the Park Street parking lot, just north of Pismo Creek, there are 150 parking spaces and several other street parking areas near the beach. At the Monarch Butterfly Grove and along State Route 1 there are 100+ additional spots, while the Grand Avenue entry ramp area has hundreds more.

Central: Very popular among tourists and locals alike, Pismo Beach central is located between the Park Street parking lot and the Pismo Pier (to the north). Surfing, bodyboarding, swimming, and sunbathing are top attractions both here and north of the pier. A boardwalk and some beach volleyball nets are present. The beach is popular with families, and there are swing sets at Park Street and just north of the pier at Main Street. There are several lifeguard towers on the beach, and showers and restrooms are available at the pier and the Park Street parking lot. A popular tourist town, there are restaurants and lodging facilities near the beach and pier. This area can get very crowded and congested at peak times. There are 250 parking spaces in the pier parking lot that are subject to parking fees. There are also 40-50 additional spots on the adjacent streets.

North: A very popular transition beach, located between the Pismo Pier and the cliff bluffs, is frequented by a large number of tourists during the summer months, primarily because of the large beach- front resorts lining this section of beach. Multiple stair access points lead to the beach, including the pier, Main Street, Wadsworth and Cypress Streets, Kon Tiki Inn, Wilmar Street, and Sea Crest Hotel. There are 40-45 free street parking spots at Wadsworth and Cypress where there are also public restrooms and showers, amenities that can also be found at the pier. Wilmar Street also has 13 to 15 free street parking spaces. People walk their dogs on the most northern section of the beach by the cliffs, farther from the crowds of the pier area. Besides being

very popular among beach walkers and some surfers, it has many volleyball nets that get used during the summer.

7.3.4 Shell Beach

The Inn at the Cove Beach: A small, rock-and-sand beach that is located down a steep stairway and trail. Bluffs of sandstone carve out the landscape above the beach, which is constantly crumbling because of erosion. Low tide provides tide pools and good rock collecting. This beach is occasionally accessed by fisherman, from both the bluffs and beach. Kayakers frequent the cove on tours from other Shell Beach access points. There are a few public access parking spaces (4 or 5) here, but there are 12 to 15 spaces up the road at a parking area on Price Street.

Shell Beach-Margret Dodd (aka 1,000 steps): A small, grassy park and gazebo mark this location, with the large bluffs and tapering low cliffs that are common throughout Shell Beach. Seabirds, otters, and seals are often seen from this beach. Switchback stairs lead to a cove with a sandy beach and tide pools at low tide. Kayakers and paddle boarders commonly launch here. There are many parking areas on the street with at least 25 spaces near the beach stairs.

Shell Beach-Eldwayen Ocean Park beach: Bluff Beach Park, on Ocean Boulevard, has walking paths, sitting benches, a grassy area and short stairs to rock-and-sand beach. This reach is the best kayak launch spot on this section of coast. There is, however, little beach left at high tide. There are over 100 parking spaces along Ocean Boulevard and its residential side streets.

Shell Beach-Spyglass Park Beach: A nice park area with playground, bathroom facilities, sitting benches and a couple tables. The park is situated above a moderately steep path that descends to a rocky tide pool and a narrow beach area. The beach is more accessible at low tide, as are several other narrow beaches in this area. This beach is popular among surfers and its parking lot, which is rarely full, has 40 spaces.

7.3.5 South Palisades Park

Popular among college students, this long and narrow beach can be accessed from a trail adjacent to the Cliffs Resort. Although there is minimal public parking at the resort itself, other parking is available in a lot situated about 1/8 mile north of the resort. This trail and stairway meanders down a densely vegetated canyon, providing shoreline access for a few other resorts that neighbor The Cliffs. There is also a northern access point to this beach at Palisades Park via Beachcomber Street and at Indio Drive via El Portal. There are several benches and a large grassy area to picnic on. There are 50+ parking spaces on Beachcomber and Indio Drive which allow access to this sometimes crowded location. The beach itself is long and sandy with some rocks, reefs, and tide pools. Surfing, swimming, sunbathing, and walking are popular at this beach.

7.3.6 Pirates Cove

This stretch is also known as Cave Landing because of the large cave in the bluff above the north end of the beach. It is one of the most scenic beaches in the county because of its rugged topography, prominent rocky structures, and steep backbeach cliff. With some of the most sheltered water along the coast, sailboats often anchor in the bay. The beach is accessed mostly via a semi-steep, half-mile path down to the cove. The parking area is at the end of Cave Landing Road and has approximately 75 spaces with an additional 40 to 50 street parking spaces for visitors who do not wish to park in the somewhat rutted parking area. The south end of the beach can also be accessed via Bluff Drive in Shell Beach, although there is a long hike to the beach from this access point.

7.3.7 Avila Beach

Avila Beach is one the most visited beaches in the county, especially during the summer. As a south-facing beach that is also shelter by the Port San Luis breakwater, this typically calm beach is popular among swimmers, surfers, body boarders, paddle boarders, and sun bathers. Portions of this beach are also popular student hang outs. The waterfront features shopping, restaurants, a large boardwalk area, and a nice playground area with ample restroom facilities. Although most people park for free along the adjacent streets, there is a large 300-space parking area that costs $5 per day located a block away. Finding parking during summer can be difficult, especially when concerts and other special events are held at the beachfront golf course.

7.3.8 Port San Luis Beach

A very popular beach among summer visitors and dog walkers, Port San Luis Beach (also known as Olde Port Beach) is packed during the summer months. There is a concrete ramp into the water that enables easy launching of kayaks, small sailboats, inflatable boats, jet skis, and paddle boards. Situated between the Cal Poly Pier and Harford Pier, this beach has many boats anchored just outside of the beach zone. Restrooms are available, as are numerous access points to the beach. A ¾ mile stretch of Avila Beach Drive provides 300+ parking spaces, including limited overnight parking for RV's. Restaurants, boat launching, fish market, fishing supplies, whale watching, party-boat fishing, restrooms, and showers can all be found at Port San Luis near the end of the beach. Harford Pier also allows drive-on parking.

7.3.9 Montaña de Oro State Park

Occupying many miles of coastline, Montañ a de Oro State Park is a large and diverse park and beach. Full of cliffs and tidepools, the rugged southern area of the park has walking trails, sandstone cliffs, expansive rocky plateaus and tidepools. Because of rough seas and dangerous jagged reefs, only experienced surfers and kayakers venture into this open-ocean location. In the middle of the park is Spooners Cove, a sandy cove beach within easy reach of a parking area. Because of its protected waters, kayakers and small inflatable boats launch here to access nearby

fishing and scuba diving areas. Towards its north end, the coast turns sandy for many miles up to the mouth of Morro Bay. Hazards Canyon is well known for having large waves, which makes it popular with experienced surfers. The far northern area of the park has a parking area that leads, through beach dunes, to the sand spit beach area. This beach is far less populated than the more easily accessible reaches in Morro Bay and Cayucos.

7.3.10 Morro Rock City Beach

The busiest beach in Morro Bay, this beach is bordered by Morro Rock cliff walls on the south and continues north for several miles. There are always surfers at this spot. In the off season there can be as many surfers in the water as there are visitors on the beach. The beach is accessible from several parking areas, including 300+ spaces next to Morro Rock and several other parking locations at Embarcadero and Atascadero Road. These smaller lots have 15 to 20 spaces each in addition to additional parking on nearby streets. Near the Morro Rock parking area is a small beach, called Coleman Beach, where kayaks frequently launch to paddle inside Morro Bay.

7.3.11 Morro Strand State Beach

This is an open, sandy beach that runs 2.5 to 3 miles from Toro Creek Road to 24th Street in Cuyucos. Beach walking, dog walking, kite flying, and surfing are popular activities along this section of the coast. Numerous secluded areas provide some degree of privacy for beach-goers. Parking lots are located along Toro Lane and Studio Drive, with 50 to 75 parking spaces each, in addition to ample street parking. Whale and dolphin sightings are common along this open area of Estero Bay. This beach was originally known as Atascadero Beach.

7.3.12 Cayucos Beach

This reach of varying width lies between the 24th Street parking lot (to the south) and the rocky cliff wall at 1st Street (to the north). Only busy during the summer season, this beach is separated along its edges by cliffs lined with houses. Sunbathers and beach walkers are the most common users, but occasionally there are volleyball players, swimmers and surfers. The beach is accessed via stairs spaced between the homes every few blocks with street parking available at each access point.

7.3.13 Cayucos State Beach

This beach is the hub of economic activity for Cayucos, with restaurants and shopping within a few blocks. This beach and Morro Strand State Beach are the most popular beaches along the north coast of the county. Surfing lessons are available during the summer, with rentals of suits and boards provided at the beach. This somewhat protected beach allows for easy surfing and kayak launching. There are also many timeshares near the north end of the beach. Approximately

100 parking spaces are provided on the north and south sides of pier, along with many additional spots along Ocean Avenue and side streets.

7.3.14 Estero Bluffs to Villa Creek Road

Heading north from Cayucos, there are several pull offs along State Route 1 that have parking areas with walking trails along the bluffs leading to coastal access. Although most of these spots are rocky-reef beach zones, some of them are popular among surfers with names like "killers" and "abalones." Dog walking and day hiking are popular activities along this reach. The most northern pull off is at Villa Creek Road where there is a rocky cove with a nice sandy beach. Trails run up to a half mile from the parking area to the beach. Paddle boarders and sometimes kayakers also access the coast here. This beach has great coastal views and whale watching along the bluffs and rocky outcroppings is popular.

7.3.15 Harmony Headlands State Park (aka Nikki's Beach)

With the exception of one bathroom, there are no structures or buildings on this somewhat rugged and undisturbed beach. The trail meanders 1.5 miles into a rocky canyon that opens up to the coastal plateau. There are small cobble beaches at the end of the trail, bluffs to climb around, and decent fishing off of the rocks.

7.3.16 Harvey's Beach, Lampton Cliffs Park, Sherwood Dr. Cambria

From Sherwood Drive there are access points to the beach at the end of Harvey's Street and from Lampton Cliffs Park. A short path and stairway leads to the rock-and-sand beaches. Harvey's has more of a beach, but both spots are relatively uncrowded, drawing few visitors during the summer.

7.3.17 Fiscalini Ranch Preserve

Fiscalini Ranch Preserve is an open area of more than 400 acres, a mile of coastline, and an open wilderness area bordering the beach bluffs. The preserve has many recreational opportunities including dog walking, horseback riding, mountain biking, and hiking. Visitors sometimes spot otters, whales, and dolphins from the bluffs.

7.3.18 Moonstone Beach Park

Santa Rosa Creek Access: Commonly called Moonstone Beach because moonstones can be found on the beach. On the south end of the beach is Shamel Park, which has picnic tables, a playground, and a public swimming pool. This reach has two access points with stairs that lead down to the beach. With a steep beach profile and an open-ocean location, the area is used by experienced surfers and swimmers.

Leffingwell Landing: The reach, which is part of the Moonstone boardwalk area, has large facilities including restrooms, picnic tables, BBQs, and a small-boat launch. The concrete ramp to the beach gives boats and kayaks access to the nearby productive fishing reefs. There are approximately 30 parking spaces with a dirt overflow lot and many additional parking spaces along Moonstone Drive.

7.3.19 Hearst San Simeon State Park

Located along State Route 1, this beach at Hearst San Simeon State Park has easy parking access in two locations along with several dirt parking lots. Across from the beach are two public camping areas and bluff trails that are good for walking, sight-seeing, and whale watching. Like many of the northern beaches of the county, this area is seldom visited during the winter. The beach's steep profile lends itself to advanced surfing, windsurfing, or kayaking. Parking is not a problem because there is a good-sized dirt lot and many extra spots off State Route 1.

7.3.20 Pico Creek/Little Pico Creek

Accessible from the Pico Street cul-de-sac, this reach is a popular surfing area. Cliff areas are positioned on both the north and south ends of the beach with a fairly long and narrow sandy beach in between. Little Pico Creek is about a mile up the road with a dirt parking area and primitive dirt trails down to small sandy beach. This reach is not very popular because of the more easily accessible beaches to the north and south.

7.3.21 W.R. Hearst Memorial State Beach

The pier at the W.R. Hearst Memorial State Beach provides good facilities including restrooms, showers, kayak, and paddleboard rentals. Its close proximity to Hearst Castle also contributes to its popularity. Set inside a large, protected cove, this beach is great for swimming and kayaking. Many whales take up residence in the cove during the summer, making for great viewing from the pier or the beach. This is the last public pier south of Monterey. Through the public eucalyptus groves to the north, there are excellent walking trails leading to San Simeon Point and beyond. Small boats can be launched from the beach. Visitors also engage in fishing from the shore, kayaks, or the pier, this being the most popular option.

7.3.22 Arroyo de Laguna Beach

Although many beaches in this vicinity are closed to the public because of the large elephant seal population, Arroyo de Laguna Beach has remained open, because the seals have not actively colonized the beach. It is often called "windsurfer beach" because many windsurfers take advantage of the high wind conditions and somewhat calmer ocean that are often found here, especially in springtime. Oak Knoll Creek empties into the ocean on its south end, and nice white sand and minimal crowds make this a great choice for those seeking beauty and solitude. Ample parking is available in the dirt lot.

7.3.23 Point Piedras Blancas

This is a marine protected area for the thousands of elephant seals that congregate on the beaches here and nearby. At times there are mostly young males. Other times there are females, babies, and sometimes rivaling bull males fighting for control of the colony. Walking trails along the bluffs provide great viewing of the seals as well as hiking north to the historic lighthouse. A dirt lot accommodates roughly 200 cars, and an overflow parking lot of 30 to 40 spaces is also frequently busy with tourists. There are also portable toilets on site. The beaches adjacent to this location are closed to protect the seals.

7.3.24 Hearst Ranch/ Arroyo del Corral

Parking for these beaches is largely restricted with “no parking” and “no beach access” signs posted because of elephant seals. Because there are many seals on each of these beaches, foot traffic is restricted.

7.3.25 San Carpoforo Beach

San Carpoforo has cliff bluffs, forests, rocky beaches, and sandy beaches, all of which can be accessed by hiking about ¼ mile from State Route 1 to the beach. San Carpoforo Creek also runs through the middle of the beach, forming a lagoon. Many days there are no visitors on this beach, and it is never crowded. This location can get large surf from the west and northwest. Going north from here, the terrain shifts dramatically to rugged steep cliffs and forests that make up the Big Sur coastline. There are 10 to 12 parking spaces available along State route 1, but these are rarely fully utilized.

7.3.26 Ragged Point Inn

A public access trail has been created on the edge of a sheer cliff, creating steep, continuously traversing switch-backs down to a beach and rocky cove. This dark volcanic rocky shoreline creates a unique combination of black sand and clear, deep blue water from a lack of fine sediment. This is a somewhat advanced trail, perhaps a half mile down to the beach, with rocks, poison oak, and tree roots to contend with.

7.4 Amenities

As part of this analysis, data was collected on various amenities at each of these beaches and reaches (Table 23). Certain amenities were assessed based on judgments from extensive visitation. For example, surfing was rated subjectively on a scale of 0 to 4 with “0” indicating little or no surfing, “1” indicating a small amount of surfing, “2” indicating moderate surfing, “3” indicating a significant surf spot, and “4” indicating a major surfing spot that surfers consider a destination site. None of the surf spots in San Luis Obispo County are rated a 4. Similarly parking was rated 1 to 4, with a “1” indicating that parking is easy during all but the busiest

times (e.g., July 4), "2" indicating parking is only an issue on busy summer weekends or during special events, "3" indicating that parking may be difficult to find during busy times, and "4" indicating chronic parking issues.; Only small beaches with limited parking or access (e.g., Harmony Headlands) rated a 4, while none of the major beaches rated a 4. Overall the average was 1.6 indicating that the county generally has adequate parking at its beaches, except during very busy times.

Table 23. Amenities at Beaches in San Luis Obispo County

Sandy Beaches	Trail	Bike Trail	Camp-ground	Beach Shower	Boating Facilities	Wildlife Viewing	Fishing	Dog Friendly	Play-ground	Visitor Center	Facilities for Disabled	Food or Drink	Restrooms	Fee	Parking (1=Good-4=Bad)	Lifeguard	Surfing	Access (1=Good-4=Bad)
RaggedPoint Trail and Overlook	x				x		x	x				x	x		1			4
San Carpoforo Creek Beach	x														1		x	2
Arroyo del Corral						x									4			4
Piedras Blancas	x					x							x		1			3
Oak Knoll Creek Beach/ Arroyo Laguna	x														1			1
W.R. Hearst Memorial State Beach											x		x		1	x		1
Little Pico Creek															1			2
Pico Creek															1		x	1
Hearst San Simeon State Park	x		x			x					x		x	x	1		x	1
Leffingwell Landing	x				x	x					x		x		1			1
Moonstone Boardwalk	x							x			x				1			1
Fiscalini Ranch Preserve	x	x						x			x				1			1
Sherwood Drive Access/Harvey Beach															1			1
Harmony Headlands State Park															4			4
China Harbor (unaccessible)															4			4
Estero Bluffs State Park	x														1		x	3
Cayucos State Beach				x			x		x		x	x	x		2		x	1
Cayucos Beach								x					x		1		x	1
Morro Strand State Beach (North)/Toro Creek													x		1		x	1
Morro Strand State Beach (South)	x										x		x		1		x	1
Morro Rock City Beach							x	x			x		x		1	x	x	1
Montana de Oro State Park	x	x	x			x	x	x		x	x		x		1		x	2
Olde Port Beach/Fishermans					x			x			x		x		1	x		1
Avila Beach	x	x		x	x		x		x		x	x	x		2	x		1
Pirates Cove (aka Cave Landing)	x														2			3
South Palisades City Park	x					x		x							1		x	1
Spyglass City Park								x	x				x		1		x	2
Shell Beach - Ocean Eldwayen City Park						x		x							1		x	1
Shell Beach - Margo Dodd City Park	x					x		x							1		x	1
Shell Beach - Stairway at Shelter Cove Lodge	x										x		x		3		x	3
Pismo Beach	x	x		x				x	x		x	x	x		2	x	x	1
Oceano Dunes State Vehicular Recreation Area			x				x	x			x			x	1			1
Oso Flaco (aka Guadalupe-Nipomo Dunes)	x					x					x			x	1			4

7.5 Survey and Counts

Socioeconomic data on beach use in San Luis Obispo County is limited. California Department of Parks and Recreation requires that all state parks and beaches compile official attendance records; however the methods applied are inconsistent and often lead to inaccurate counts (King and McGregor, 2010). Further, since most beaches in the county are not state parks,

data is not generally available for those beaches. Consequently, as part of this project, we conducted human counts of beach goers at each beach in the county. For significant beaches, 10 or more counts were made between the times of 9:00 am and 7:00 pm; for less significant beaches, fewer counts were made. The date and time of day was recorded. Our analysis applied turnover factors – attendance multipliers that measure the ratio of the head count, for any given time of day, to the attendance estimate for the entire day (King and McGregor, 2010). **Error! Reference source not found.** provides estimates of annual attendance at each beach. The most popular beaches are Oceano Dunes State Vehicular Recreation Area, Pismo Beach and Avila Beach. Indeed, these three beaches account for more than half of all beach recreation in the county. As one moves farther north, attendance diminishes.

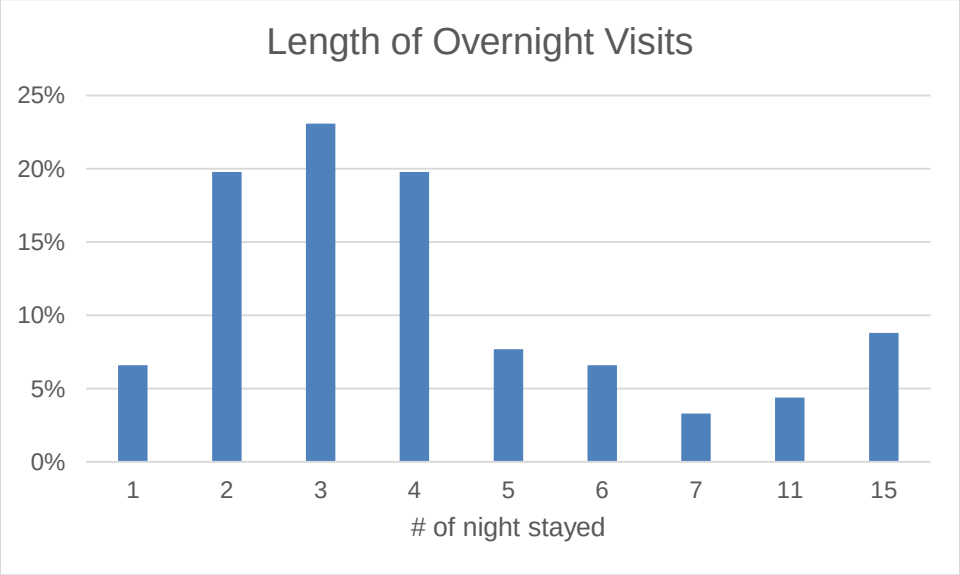
Table 24. Annual Attendance Estimates at beaches in San Luis Obispo County

Location	Attendance	Parking (1=Good-4=Bad)
Ragged Point Beach	3,000	1
San Corpoforo	2,000	1
Piedras Blancas	43,000	1
Oak Knoll Creek Beach/ Arroyo Laguna	3,000	1
W.R. Hearst Memorial State Beach	10,000	1
San Simeon Cove	9,000	1
San Simeon - Pico Creek	5,000	1
San Simeon (path)	3,000	1
Hearst San Simeon State Park	20,000	1
Leffingwell Landing	9,000	1
Moonstone-Boardwalk Beaches	11,000	1
Moonstone-Santa Rosa Creek	18,000	1
Harmony Headlands State Park	4,000	4
Cayucos State Beach	63,000	2
Cayucos Beach	50,000	1
Morro Strand State Beach	53,000	1
Morro Bay-Atascadero Beach	53,000	1
Montana de Oro-Hazards	15,000	1
Montana de Oro-Sandspit	18,000	1
Montana de Oro-Spooners	40,000	1
Olde Port Beach/Fishermans	69,000	1
Avila Beach	226,000	2
Avila Pier	78,000	2
Pirates Cove (aka Cave Landing)	20,000	2
South Palisades City Park	26,000	1
Spyglass City Park	3,000	1
Shell Beach - Eldwayen Ocean Park	10,000	1
Shell Beach - Margo Dodd City Park	13,000	1

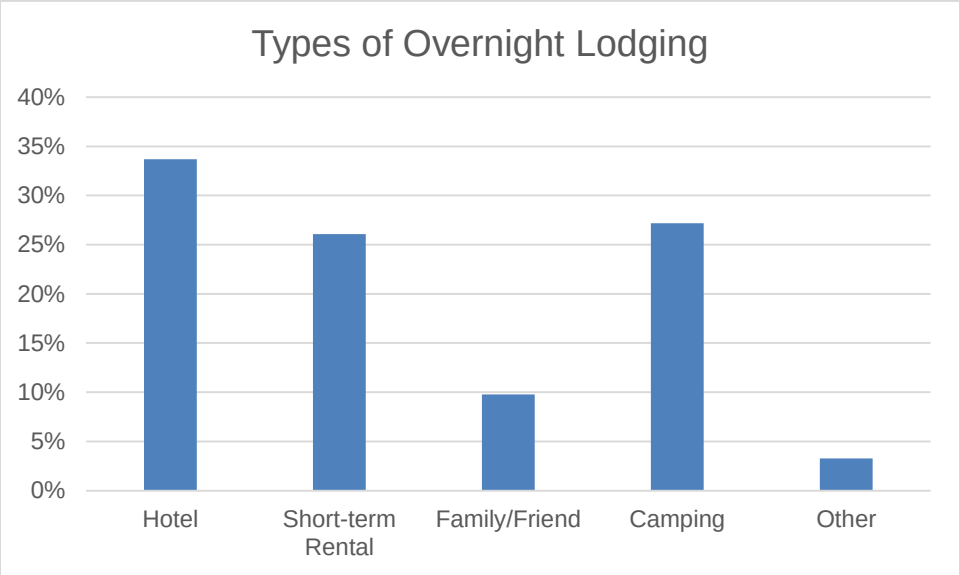
Shell Beach - Shelter Cove Lodge	4,000	3
Pismo State Beach (Northern)	140,000	2
Pismo State Beach (Central)	121,000	2
Pismo State Beach (Southern)	74,000	2
Pismo Pier	75,000	2
Oceano Dunes SVRA	1,500,000	1
Oso Flaco (aka Guadalupe-Nipomo Dunes)	19,000	1
Total	2,810,000	

To get some sense of visitation to beaches in the county, a brief (one-page) survey was conducted. The most important conclusions from the survey are:

- Half of all visitors to beaches in the county are overnight visitors; the other half are on day trips.
- The average length of an overnight stay is 4.7 nights



- Overnight lodgings are primarily and relatively evenly distributed among hotels, short-term rentals and camping.



7.6 Economic Analysis

As part of this analysis, the economic impact of beach spending in San Luis Obispo County was estimated, using methodologies described in King (1999). Table 25 presents annual estimates of State and Local (City/County) sales taxes and City Transient Occupancy Taxes (TOTs).[2] Overall, the total spending in the County is just over $52 million; this generates $1.6 million in State sales taxes and $2.5 million in local taxes, mostly TOTs.

Table 25. Direct spending and taxes Generated by beach recreation in San Luis Obispo County

Location	Total Spending	State Tax	Local Tax	City TOT	Total City Taxes	Rec Value
Ragged Point Beach	$80,700	$2,800	$400	$3,500	$3,900	$103,800
San Corpoforo	$70,000	$1,800	$300	$3,000	$3,300	$90,000
Piedras Blancas	$1,304,300	$39,700	$6,100	$56,000	$62,100	$1,678,000
Oak Knoll Creek Beach/ Arroyo Laguna	$86,500	$2,800	$400	$3,700	$4,100	$111,200
W.R. Hearst Memorial State Beach	$305,000	$9,200	$1,400	$13,100	$14,500	$392,400
San Simeon Cove	$259,100	$8,300	$1,300	$11,100	$12,400	$333,300
San Simeon - Pico Creek	$161,000	$4,600	$700	$6,900	$7,600	$207,200
San Simeon (path)	$78,000	$2,800	$400	$3,400	$3,800	$100,400
Hearst San Simeon State Park	$608,900	$18,400	$2,800	$26,100	$29,000	$783,300
Leffingwell Landing	$280,900	$8,300	$1,300	$12,100	$13,300	$361,400
Moonstone-Boardwalk Beaches	$347,200	$10,100	$1,600	$14,900	$16,500	$446,700
Moonstone-Santa Rosa Creek	$558,300	$16,600	$2,600	$24,000	$26,500	$718,300
Harmony Headlands State Park	$122,700	$3,700	$600	$5,300	$5,800	$157,800
Cayucos State Beach	$1,906,100	$58,100	$8,900	$81,900	$90,800	$2,452,300
Cayucos Beach	$1,501,900	$46,100	$7,100	$64,500	$71,600	$1,932,200
Morro Strand State Beach	$1,598,200	$48,900	$11,300	$68,600	$79,900	$2,056,200
Morro Bay-Atascadero Beach	$1,617,400	$48,900	$11,300	$69,500	$80,700	$2,080,800
Montana de Oro-Hazards	$449,800	$13,800	$2,100	$19,300	$21,400	$578,700
Montana de Oro-Sandspit	$532,200	$16,600	$2,600	$22,900	$25,400	$684,700
Montana de Oro-Spooners	$1,216,900	$36,900	$5,700	$52,300	$57,900	$1,565,700
Olde Port Beach/Fishermans	$2,106,700	$63,600	$9,800	$90,500	$100,300	$2,710,400
Avila Beach	$6,837,000	$208,400	$32,100	$293,600	$325,700	$8,796,200
Avila Pier	$2,366,000	$71,900	$11,100	$101,600	$112,700	$3,044,000
Pirates Cove (aka Cave Landing)	$607,000	$18,400	$2,800	$26,100	$28,900	$780,900
South Palisades City Park	$794,600	$24,000	$5,500	$34,100	$39,700	$1,022,300
Spyglass City Park	$90,600	$2,800	$400	$3,900	$4,300	$116,500
Shell Beach - Eldwayen Ocean Park	$301,400	$9,200	$2,100	$12,900	$15,100	$387,700
Shell Beach - Margo Dodd City Park	$396,500	$12,000	$2,800	$17,000	$19,800	$510,100
Shell Beach - Shelter Cove Lodge	$118,100	$3,700	$900	$5,100	$5,900	$151,900
Pismo State Beach (Northern)	$4,258,600	$129,100	$29,800	$182,900	$212,700	$5,479,000
Pismo State Beach (Central)	$3,661,900	$111,600	$25,700	$157,300	$183,000	$4,711,300
Pismo State Beach (Southern)	$2,236,800	$68,200	$15,700	$96,100	$111,800	$2,877,800
Pismo Pier	$2,262,300	$69,200	$16,000	$97,200	$113,100	$2,910,600
Oceano Dunes SVRA	$45,469,954	$1,383,256	$212,809	$1,952,742	$2,165,551	$58,500,000
Oso Flaco (aka Guadalupe-Nipomo Dunes)	$562,900	$17,500	$2,700	$24,200	$26,900	$724,100
Total	**$83,700,454**	**$2,546,956**	**$432,309**	**$3,594,842**	**$4,026,651**	**$107,685,400**

In addition to measuring direct spending, we can also measure the indirect and induced effects (i.e., multiplier effects) generated by beach recreation spending (Table 26). Essentially, these estimates include the additional spending and jobs generated by this economic activity. For example, if a person who rents out windsurfing boards spends the income he generates through his business on other items, that would be included. Overall, the county beaches generate a total economic impact of $171.1 million and generates an estimated 2,124 jobs.

Table 26. Economic Impact of Beach Spending in San Luis Obispo County

Impact Type	Employment	Labor Income	Output
Direct Effect	1,682	$50,625,595	$107,685,400
Indirect Effect	144	$6,137,971	$24,354,929
Induced Effect	298	$11,886,870	$39,104,536
Total Effect	2,124	$68,650,436	$171,144,865

An economic impact analysis of Port San Luis and Morro Bay Harbor was also conducted to support plan development. It is worth noting that there is some overlap between the beach spending for the entire county (above) and the spending at the port and harbor (below). Unfortunately, without access to finer grained data, there is no way of measuring this overlap

Morro Bay Harbor provides space for commercial and recreational fishing and boat launching for smaller boats (mostly recreational fishers) in addition to leasing a substantial amount of space to local retailers and service industries that cater to Morro Bay visitors. Fortunately, the Morro Bay Harbor District keeps records of boat launches and mooring, commercial fish catches, and sales at the businesses which lease space from the harbor. Table 27 summarizes these data.

Table 27. Direct Spending at Morro Bay Harbor

Morro Bay		Per Person	Spending
Budget			$1,975,000
Parking			$25,000
Commercial Fishing			$7,100,000
Sales			$27,295,900
Fish Spending (# of parties)		23,150	
	Food	$19.66	$455,068
	Lodging	$9.13	$211,272
	Transport	$18.16	$420,500
	Boating costs	$22.22	$514,421
	Others	$18.95	$438,711
Total			$38,435,872

Overall the port generates $38.5 million in spending. Sales from stores, restaurants, and service providers leasing space from the harbor ($27.3 million) constitute the single largest category, followed by commercial fishing ($7.1 million).

In addition to measuring direct spending, the indirect and induced (aka multiplier) effects generated by the Morro Bay Harbor spending (Table 28) were estimated. Essentially, these estimates include the additional spending and jobs generated by this economic activity. For

example, if a commercial fisherman spends the income he generates through the port on other items that would be included. Overall, the harbor generates a total economic impact of $61 million and generates 758 jobs.

Table 28. Total Economic Impact of Morro Bay Harbor

Impact Type	Employment	Labor Income	Output
Direct Effect	600	$18,069,663	$38,435,872
Indirect Effect	51	$2,190,810	$8,692,942
Induced Effect	106	$4,242,750	$13,957,481
Total Effect	758.1	$24,503,223	$61,086,295

Port San Luis also provides slips for commercial and recreational fishing, and boat launching for smaller boats (mostly recreational fishers) and leases some space to restaurants and service industries. In addition, Port San Luis provides significant camping opportunities. Table 29 summarizes these data. Overall the port generates $9.5 million in spending. The port budget ($6.3 million) constitutes the single largest category, followed by commercial fishing ($2.1 million).

Table 29. Direct Spending at Port San Luis

San Luis		Per Party	Total Spending
Budget			$6,263,200
Parking			$350,000
Commercial Fishing			$2,057,613
Camping Spending (# of parties)		11,303	
	GAS	$18.65	$210,775
	FOOD AT RESTAURANTS	$19.83	$224,099
	BEER WINE LIQOUR	$5.25	$59,356
	SUNDRIES	$4.61	$52,088
	FOOD AT STORES	$21.86	$247,115
Total			$9,464,246

In addition to measuring direct spending, we can also measure the indirect and induced effects (i.e., multiplier effects) generated by Port San Luis spending (Table 30). Overall, the port generates a total economic impact of $15.8 million and generates an estimated143 jobs.

Table 30. Total Economic Impact of Port San Luis

Impact Type	Employment	Labor Income	Output
Direct Effect	97	$4,271,601	$9,464,246
Indirect Effect	20	$928,205	$2,768,623

Induced Effect	27	$1,078,766	$3,544,496
Total Effect	143	$6,278,572	$15,777,365

7.7 Policy Issues

As is the case for 80 percent of the California coastline (Griggs, 1998), parts of the shoreline in the county are actively eroding. Sea-level rise is likely to exacerbate this erosion. According to Heberger (2009, Table 8, p.42), coastal erosion in the county will have a negative impact on coastal businesses and households, although the magnitude of the damages is smaller than in many areas. Heberger (2009) estimates that with a 1.4-m sea level rise by 2100, will potentially affect 1,300 county residents (out of an estimated total of 210,000 for the entire state).

8. RECOMMENDED REGIONAL SEDIMENT MANAGEMENT STRATEGIES

Suggested Plan strategies presented below (Table 31) are based primarily on issues discussed in previous sections. Those strategies were developed using input from Plan sponsors and stakeholders.

Three types of activity modifiers are provided:

- *Type* is separated into the following:
  - Performance activities are designed to improve performance of the CRSMP. This includes monitoring and feedback activities which could inform other CRSMP activities for better decision making. These are typically research, investigations, and studies.
  - Construction activities are projects that can be built and support coastal regional sediment management.
- *State* separates strategies based on activity, between those that are existing and are expected to continue into the future and those that merely have the potential to begin (i.e., have not yet begun).
- *Duration* separates activities into those that are projects that can be completed, those that would be ongoing without end, and those that would be recurring without end.

Table 31. Summary of Potential CRSMP Strategies

Activity	Type	State	Duration
Support Piedras Blancas Realignment	Construction	Existing	Project
Investigate nourishment at Cayucos	Construction	Potential	Project
Continue Morro Bay dredging & disposal	Construction	Existing	Recurring
Investigate Landward Migration of Morro Bay Sand Spit	Performance	Potential	Project
Continue Port San Luis dredging	Construction	Existing	Recurring
Assess Port San Luis sand retention methods	Construction	Potential	Recurring
Investigate Pismo Beach nourishment with Port San Luis dredge material	Construction	Potential	Recurring
Support the sediment management plan for the Twitchell Reservoir	Performance	Existing	Project
Investigate sea level rise adaptation strategies and beach sustainability	Performance	Potential	Recurring
Update sediment budget for Santa Maria Littoral Cell	Performance	Potential	Project
Develop local Sand Compatibility and Opportunistic Use Program	Performance	Potential	Ongoing
Investigate methods to assess and mitigate for upstream sand taking	Performance	Potential	Project
Support coastal shoreline setbacks in SLO County LCP	Performance	Existing	Ongoing
Develop stream floodplain setbacks	Performance	Potential	Project

8.1 Support Piedras Blancas Realignment

The Piedras Blancas Realignment is underway, as grading for the highway realignment recently started. This inland realignment of State Route 1 preserves coastal sediment in its natural place while at the same time reducing the need for hard shoreline protection structures. This allows natural processes to maintain the beach and its natural aesthetics. This project is supported by SLOCOG in its Federal Transportation Improvement Program (FTIP). SLOCOG and the County of San Luis Obispo submitted letters of support to Caltrans, and continue to inform the public of their role in the project.

8.2 Investigate nourishment at Cayucos

From various sources, it seems clear that erosion and future flooding threaten the low lying and bluff areas of Cayucos. The community has a number of residential and commercial structures at low elevations just behind the main beach area, with structures farther from the shoreline generally at higher elevations and thus less vulnerable to coastal flooding. Since there is excess sediment available from the Morro Bay dredging project, it seems logical to investigate

whether this material could be placed in Cayucos to offset or mitigate these threats. The investigation should consider at a minimum, the economics (e.g., benefits, costs, and funding sources), environmental impacts, and community interest in such projects. Also important would be the loss of ongoing nourishment at the Morro Bay Strand and Sand Spit.

A full analysis of adaptation strategies for Cayucos would involve the following: (1) The creation of a series of hazard maps tied to different climate change/sea level rise scenarios; (2) an accounting of the assets at risk in these scenarios, and; (3) an economic analysis of the costs and benefits of each of these strategies. Without such a comprehensive analysis, it is impossible to ascertain which policy is the most cost-effective. It should be noted, however, that a detailed study of these options in southern Monterey Bay (citationPWA, 2012), which has similar demographics, found that coastal armoring was not cost-effective.

8.3 Continue Morro Bay dredging and disposal

This strategy continues the ongoing maintenance dredging of the Morro Bay Entrance Channel, Navy Channel, and Morro Channel. Since material from this project naturally replenishes many beaches in the littoral cell through sediment transport, it is an example of existing coastal regional sediment management. This activity should be considered within the larger region including changes in disposal locations, perhaps including Cayucos. Supporting efforts could include continuing local funding, seeking project partners, and adding the project to local legislative platforms.

8.4 Investigate Landward Migration of Morro Bay Sand Spit

Investigate whether the landward migration of the Morro Bay Sand Spit is problematic. If it is, assess possible solutions to this problem, including RSM solutions such as use of excess sand elsewhere.

8.5 Continue Port San Luis dredging

The ongoing dredging program at Port San Luis should continue to keep the Port operations functional as described in Section 3.1.2 of this report. Strategies that would modify the existing dredging program are described below. Supporting efforts could include continuing local funding, seeking project partners, and adding the project to local legislative platforms.

8.6 Assess Port San Luis sand retention methods

There are a handful of potential construction projects that might improve the efficiency of the ongoing maintenance efforts in Port San Luis. These include installation of a sand trap groin, sand trap pit, and changing dredge disposal locations as described in Section 3.1.2. The first step would be to conduct assessments and modeling on the viability of these potential projects.

Supporting efforts could include seeking project partners and adding the project to local legislative platforms.

8.7 Investigate Shell beach and Pismo Beach nourishment with Port San Luis dredge material

It has been suggested (CCC, 2008) that sediment from the Port San Luis maintenance dredging efforts could more beneficially be used in the region if it were transported to and deposited at Pismo Beach, including Shell Beach, where problematic bluff erosion has been noted. These nourishment sites could have multiple potential benefits including reducing the dredging frequency in Port San Luis; reducing the erosion rates in the Shell Beach area of Pismo Beach; and offsetting future beach loss from sea level rise. All these assumptions would require verification through research. In addition, the nourishment sites would have to be screened for environmental impacts, community interest, and economic considerations.

8.8 Support the sediment management plan for the Twitchell Reservoir

This strategy involves supporting the SBCWA and Santa Maria Valley Water Conservation District sediment management plan for the Twitchell Reservoir. This management plan would ideally develop means and methods to restore the reservoir capacity while at the same time restoring sediment to the downstream watershed and littoral zone. This plan may provide useful lessons for the numerous other dams and reservoirs within San Luis Obispo County. Supporting efforts could include support letters and regulations for grant approval.

8.9 Investigate sea level rise adaptation strategies and beach sustainability

This potential activity would entail performing an engineering and economics study to determine the nourishment requirements necessary to offset projected sea level rise impacts throughout the San Luis Obispo County coastline and to find potential managed retreat options within the County. This study would have three foci: 1) to determine whether, where, and how much beach and nearshore nourishment would be necessary to offset sea level rise impacts on the San Luis Obispo County coast; 2) to determine whether and how much these nourishments would exacerbate rainfall runoff flooding; and 3) to find locations where managed retreat is a viable economic adaptation option against sea level rise. The study would include a calculation of the recreational and flood damage costs of unmitigated shoreline erosion resulting from sea level rise. In addition, it would include preliminary solutions at specific locations with associated impacts and costs. Results from this study would be used in long-term planning for the San Luis Obispo County coast.

8.10 Update sediment budget for Santa Maria Littoral Cell

The sediment budget for the Morro Bay Littoral Cell was estimated by the USACE in 1991 and Griggs in 2005, so it may be sufficient for future planning purposes. The sediment budget for the Santa Maria Littoral Cell was developed almost 50 years ago (Bowen and Inman, 1966) and extensive changes in the system have likely occurred since that time. This potential activity would require update of sediment transport and sediment budget estimates for the Santa Maria Littoral Cell to be more recent and relevant.

8.11 Develop a local sand compatibility and opportunistic use program

This activity would implement a regional SCOUP within San Luis Obispo County by utilizing the previously described SCOUP developed for the CSMW (Moffatt & Nichol, 2006. The SCOUP was developed to streamline regulatory approval of small (less than 150,000 yd^3) beach nourishment projects using opportunistic sediment. To carry out this process, a candidate government entity (e.g., county, city, special district or joint powers authority) would begin by evaluating potential receiver sites for need, community support, and construction accessibility. Once the receiver site or group of sites are chosen, identification and evaluation of potential sediment sources and stockpile locations is recommended, followed by a stepwise process as detailed in the SCOUP). Suggested receiver beaches that could potentially benefit from a SCOUP program include Cambria, Cayucos, Avila, and Shell Beach.

8.12 Support coastal shoreline setbacks in the Local Coastal Program

The setback requirements in the San Luis Obispo County LCP are briefly described in Section 4.2 of this report. If rigorously enforced, these setbacks can minimize negative effects of coastal development and help to maintain natural littoral processes. While the LCP is clear, difficulties often occur during interpretation and implementation of LCP policies. Supporting efforts could include educating local and State representatives in the purpose, meaning, and value of these setbacks and consistent and uniform application throughout the county.

8.13 Encourage stream floodplain setbacks

Like development setbacks provided on the coast, setbacks on stream floodplains can also serve to protect the public interest. Clear examples of threatened development on low-lying river and stream floodplains already exist in the County. Flooding is expected to get even worse with increases in future sea levels. Setback and other limits on stream and river floodplain development have the potential to minimize these ongoing and future flood pressures.

8.14 Investigate methods to assess and mitigate for upstream sand taking

This strategy involves a study to identify methods to assess and mitigate for removal of beach-quality sand from upstream creeks, streams, and river beds. Also included would be methods to assess and mitigate for upstream and coastal taking of sediment by development.

9. SAN LUIS OBISPO CRSMP IMPLEMENTATION AND GOVERNANCE STRUCTURE

9.1 Overview of Plan Implementation

This Plan is a guidance document that provides a framework for regional stakeholders to use in addressing issues associated with sediment imbalances along the San Luis Obispo County coast and environs. How (governance), when and whether the Plan is implemented are decisions to be made by the stakeholders potentially affected by the Plan. This section provides an overview of what CRSMP implementation entails in general, and provides examples of how other CSMW-sponsored Plans have approached governance and implementation, as well as a range of potential options that could be pursued for implementing this Plan. It also provides a preliminary list of recommended next steps for initiating the implementation process as well as potential short-term, long-term, and ongoing implementation actions.

The Plan provides guidance to regional stakeholders by recommending a number of potential opportunities for regional sediment management. Simply put, implementation of the Plan would involve a coordinated effort among stakeholders to establish and maintain a regional sediment management program and to evaluate and carry out these recommendations. Identifying and developing a governance structure that will support these activities is needed if the implementation program is to be successful. The Plan recommends a diverse set of sediment management measures and planning processes, which are distributed widely throughout the various sub-regions. For example, some of the recommendations in the Plan involve continuation of existing activities, whereas others could lead to entirely new projects or planning processes that will require additional funding, staffing resources, and feasibility studies. Although local jurisdictions will continue to independently plan and implement individual projects, implementation of this Plan allows for a coastal RSM program that provides many potential benefits from a regional perspective through stakeholder coordination and cross-jurisdictional collaboration.

Full implementation of this Plan will require extensive coordination among numerous overlapping jurisdictions including state and federal agencies, local jurisdictions, and a variety of other stakeholders. One of the first steps necessary for initial Plan implementation is to connect the relevant stakeholders, including agencies and local municipalities, to begin collaborative discussions on options for staffing and long-term implementation of this Plan. The SLOCOG Board will make final decisions using a CRSMP Policy Advisory Committee, who will seek input from the Stakeholder Advisory Group on coastal matters before advancing their recommendations to the full SLOCOG board. SLOCOG will seek funding and staffing to facilitate stakeholder coordination and outreach, evaluate and recommend various funding opportunities, and investigate a regional permitting program.

The success of this Plan depends on active stakeholder involvement and coordination. Implementation requires the SLOCOG Board, working through the CRSMP Policy Advisory Committee and the CRSMP Stakeholder Advisory Group, to coordinate RSM activities and provide strategic leadership for planning and stakeholder outreach efforts.

At a minimum this Plan can benefit agencies, local jurisdictions, and other stakeholders as a technical reference that contains the best-available and most-recent scientific information regarding the geology, geomorphology, physical and biological processes, coastal erosion threats, and RSM issues. The Plan can be referred to as a reliable source of information while making planning and permitting decisions at the local, state, and federal levels.

For example, the Southern Monterey Bay CRSMP (PWA, 2008) is a widely used source of technical information that is often cited as a reference for planning and permitting decisions. With a better understanding of the geological, physical, and biological processes and the specific threats from coastal erosion and sediment impairment issues in the region, coastal decision makers can make improved sediment management decisions, and develop more effective policies and practices.

In addition to being a useful technical reference, this Plan can serve as a valuable planning resource providing local jurisdictions and agencies with a framework for using RSM to address sediment imbalance issues within San Luis Obispo County. It provides an inventory and assessment of sediment issues and coastal erosion threats, recommendations for RSM measures and stakeholder processes, and tangible next steps for initial implementation. Thus, it provides a framework that will allow local stakeholders to further evaluate, prioritize, and pursue specific projects on a cooperative basis. Moreover, the availability of information in the Plan, including identification and assessments of beaches of interest and SICHs, will provide the opportunity for sediment management issues to be addressed proactively and comprehensively rather than on an emergency, last-minute basis, which could allow for more effective solutions with fewer environmental impacts.

Another key benefit of implementation is improved agency and institutional collaboration. Such efforts can result in increased efficiency and effectiveness in addressing RSM issues and provide new opportunities for information sharing, while leveraging financial and manpower resources. The development of partnerships among permitting agencies, municipalities, researchers, and other stakeholders can lead to potential benefits including reduced study costs, enhanced protection of environmental resources, and the streamlining of regulatory processes.

In addition to the benefits described above, there are the actual benefits that could be accrued by implementing actual selection of these RSM measures. For example, implementation of this Plan can provide new opportunities for local RSM projects, such as beach restoration, to be pursued. These projects could provide several direct benefits to the region including: mitigating shoreline erosion and coastal storm damage; allowing for biological habitat restoration and

protection; increasing natural sediment supply to the coast; and providing public safety, access and recreational benefits.

Finally, having an active RSM program in the region can increase the likelihood of receiving funding from a variety of sources. For example, a clear benefit of having an adopted this CRSMP in the region is that it provides new opportunities to cooperatively apply for grants and other funding from various state, federal, and private sources. An adopted CRSMP also demonstrates to potential funders that there is a serious regional commitment to pursue RSM along with a high level of stakeholder collaboration, which is becoming important criteria to funder when assessing allocations of increasingly scarce financial resources.

9.1.1 Overview of RSM Plan Implementation Fundamentals

Although each RSM Plan is unique and tailored to a specific region and set of circumstances, there are several fundamental implementation elements that CRSMPs typically have in common. With the decision by SLOCOG to serve as the governing body of elected officials responsible for coordinating the CRSMP implementation, using their Policy Advisory Committee to provide an interface with the Stakeholder Advisory Group, it is recommended that implementation of the San Luis Obispo County CRSMP include the following activities:

- develop and implement an outreach and education program,
- establish and maintain a dedicated funding source, and
- investigate and pursue options for a streamlined (e.g., regional) permitting program.

Each one of these recommended activities is described in more detail in this section and examples are also provided from other CRSMPs developed for various regions along coastal California.

9.2 Development of a Governance Structure for Plan Implementation

To fully implement this Plan, SLOCOG will serve as the coordinated CRSMP implementation body that has appropriate jurisdictional authorities. They have the ability to enter into contracts, oversee staffing resources, and facilitate a process for input and collaboration with local stakeholders as well as federal, state, regional, and local entities. SLOCOG will coordinate with agencies and active sediment management programs in existence prior to the development of those plans.

The next steps related to Plan implementation include:

1. Officially adopting the Plan,
2. Investigate funding for coordinating activities
3. Establish and maintain a coordination mechanism among the participating stakeholders that clearly states roles and responsibilities and formalizes the process
4. Establish any needed administrative procedures,

5. Seek funding and entering into contracts to conduct studies and collaborative planning efforts, and
6. Seek funding to maintain staff necessary to coordinate CRSMP implementation activities.

9.3 San Luis Obispo CRSMP Governing Board

The San Luis Obispo County CRSMP is governed by the SLOCOG Board. Their CRSMP Policy Advisory Committee will review recommendations sent forward by the CRSMP Stakeholder Advisory Group or SLOCOG staff prior to forwarding their recommendations to the SLOCOG Board for action regarding CRSMP issues.

9.3.1 SLOCOG Board:

The twelve member SLOCOG Board is comprised of all five County Supervisors representing each of the five supervisorial Districts, and one member from each of the seven incorporated Cities

9.3.2 SLOCOG CRSMP Policy Advisory Committee

The SLOCOG Board appointed a standing committee of seven elected officials representing coastal communities. The Policy Advisory Committee has been formed to provide policy guidance to the full SLOCOG Board for the adoption of the Plan and potential implementation of Plan components. The make-up of the Policy Advisory Committee includes:

- Two County Supervisors from the three coastal supervisorial areas (Districts 2,3, and4);
- One representative from each of the three coastal cities
  - City of Grover Beach
  - City of Morro Bay, and
  - City of Pismo Beach;
- One representative from the Port San Luis Harbor District
- One representative from the Oceano Community Services District

9.3.3 CRSMP Stakeholder Advisory Group

The SAG is comprised of individuals and organizations with an interest in coastal issues. SLOCOG staff will take on the role of chair for the SAG, consulting with the CRSMP Work Group and convening the San Luis Obispo SAG when needed, identifying the issues and gathering input from the SAG and then forwarding recommendations to the San Luis Obispo CRSMP Policy Advisory Committee. The following agencies and organizations have been invited to participate in SAG activities to-date. Attendance has averaged about 20 representatives from various organizations at each of the previous meetings of the SAG. Increased participation is anticipated with the release of this CRSMP.

Groups and organizations participating in the development of the San Luis Obispo County CRSMP include:

San Luis Obispo Council of Governments (SLOCOG)
U.S. Army Corps of Engineers, Los Angeles District (USACE)
U.S. Army Corps of Engineers, San Francisco District (USACE)
Department of Agriculture (USDA)
California Coastal Commission: Central Coast Area (CCC)
California Department of Fish and Wildlife (CDFW)
California Department of Parks and Recreation (CDPR)
California Department of Transportation (Caltrans)
California Geological Survey (CGS)
California Natural Resources Agency (CNRA)
Central Coast Regional Water Quality Control Board (RWQCB)
City of Grover Beach
City of Morro Bay
City of Pismo Beach
Morro Bay Harbor District
San Luis Obispo County Planning and Building Department
San Luis Obispo County Public Works Department
Coastal San Luis Resource Conservation District
Port San Luis Harbor District
Los Osos Community Advisory Council
California Native Plant Society
Central Coast Salmon Enhancement
Morro Bay National Estuary Program
Northern Chumash Tribal Council
San Luis Obispo County Farm Bureau
San Luis Obispo Science and Ecosystem Alliance (SLOSEA)
SLO Coast Keeper

9.3.4 Additional groups and organizations invited to participate in the development of the SLO County CRSMP

U.S. Department of Interior
U.S. Environmental Protection Agency, Region IX
U.S. Forest Service
U.S. Geological Survey
U.S. Department of Agriculture, Natural Resources Conservation Service
U.S. Fish and Wildlife Services, Guadalupe-Nipomo Dunes National Wildlife Refuge
California Coastal Conservancy
California Department of Conservation
California Department of Forestry and Fire Protection
California Department of Parks and Recreation, Hearst Castle
California Department of Parks and Recreation, Oceano Dunes State Vehicular Recreation Area (SVRA)
California Department of Water Resources
California Office of Historical Preservation (OHP)

California State Lands Commission
City of Arroyo Grande
City of San Luis Obispo
San Luis Obispo County Department of Agriculture/Weights and Measures
San Luis Obispo County Environmental Coordinator
San Luis Obispo County Parks and Recreation
San Luis Obispo County Water Resources Advisory Committee (WRAC)
Avila Beach Community Services District
Cambria Community Services District
Cayucos Community Services District
Los Osos Community Services District
Los Osos Community Services District
Nipomo Community Services District
Oceano Community Services District
Oceano Community Services District
San Simeon Community Services District
Avila Valley Advisory Council
Cayucos Citizens Advisory Council
Los Osos Community Advisory Council
North Coast Advisory Council
Oceano Advisory Council
South County Advisory Council
Avila Beach Community Foundation
Central Coast Women for Fisheries
Coastwalk
Environmental Center of San Luis Obispo (ECOSLO)
Guadalupe-Nipomo Dunes Center
Land Conservancy of San Luis Obispo County
League of Women Voters of San Luis Obispo County
Morro Bay Fishermen Association
Morro Bay Yacht Club
Native American Heritage Commission
Port San Luis Commercial Fishermen's Association
San Luis Obispo County Visitors and Conference Bureau
San Luis Yacht Club
Sierra Club Santa Lucia Chapter
Monterey Bay National Marine Sanctuary
Surfrider Foundation
The Nature Conservancy

10. REFERENCES

AECOM. 2011. *San Luis Obispo County 2040 Regional Growth Forecast.* Prepared by AECOM Technical Services for San Luis Obispo Council of Governments (SLOCOG). https://library.slocog.org/PDFS/SPECIALPROJECTS/SLOCOUNTY2040REGIONALGROWTHFORECAST_AUG2011.PDF

Battalio, Bob. 2015. *Climate Change, Coastal Hazards, Mapping and Shoreline Response Modeling in California*. Flood Management Association, State Conference, 2015. September 11, 2015.

Bowen, A. J., and Inman, D. L.. 1966. *Budget of Littoral Sands in the Vicinity of Point Arguello, California*. Technical Memorandum No. 19. U. S. Army Coastal Engineering Research Center. December 1966.

Bromirski, et al, 2003.

Burton, E.J. and Lea, R.N.. 2013. Checklist of Fishes Known to Occur in Monterey Bay National Marine Sanctuary. Version 1. September 2013. Available at: http://montereybay.noaa.gov/research/techreports/mbnms_fishes_checklist.pdf.

California Coastal Records Project, 2015. www.californiacoastline.org. [Access Date]

Calcoastnews.com. 2014. "Morro Bay picks new site for sewage plant". http://calcoastnews.com/2014/12/morro-bay-picks-new-site-sewage-plant/. December 11, 2014

California Department of Water Resources, 2015. Division of Safety of Dams http://www.water.ca.gov/damsafety/damlisting/index.cfm

Californiabeaches.com. http://www.californiabeaches.com/central/san-luis-obispo-county/san-simeon/

Caltrans. 2010a. *Piedras Blancas Realignment On Highway 1 near the Piedras Blancas Lighthouse SLO-1-PM 64.0/R67.2 05-492800 SCH #2008031059 Final Environmental Impact Report with Finding of No Significant Impact*. August 2010.

Caltrans. 2010b. *Project Fact Sheet Piedras Blancas Realignment 05-49280 - SLO-1 PM 64.0/R67.2 Near San Simeon From Point Piedras Blancas to North of Arroyo de la Cruz Bridge*.

CCC, 2008., *W11a, Coastal Development Permit Application. 3-08-038, Port San Luis Harbor District Dredging*. California Coastal Commission. 8/9/08.

CCC, 2015. Sea Level Rise Policy Guidance, August 12, 2015. California Coastal Commission http://www.coastal.ca.gov/climate/slrguidance.html.

CDBW and SCC. 2002. *California Beach Restoration Study*. California Department of Boating and waterways and State Coastal Conservancy. Sacramento, California.

CDPR. 2014. Annual Report for the Western Snowy Plover at San Luis Obispo Coast District in 2014. California Department of Parks and Recreation

Chambers Group, Inc. 2011. *Final Pismo Beach Shoreline Protection Project Environmental Assessment/ Mitigated Negative Declaration*. Prepared for Los Angeles District U.S. Army Corps of Engineers. November 2011.

City of Morro Bay. 2004. *General Plan/Local Coast Plan.* Approved 2004

City of Morro Bay. 2010. Harbor News. Volume 10, Issue 1. Winter 2009-2010.

City of Morro Bay. 2015. "NEW Water Reclamation Facility (WRF)." http://www.morro-bay.ca.us/index.aspx?NID=759. August 19, 2015

City of San Luis Obispo. 2015. Utilities Department, Water Resources. http://www.slocity.org/government/department-directory/utilities-department/water/water-sources August 26, 2015

Coastal San Luis Resource Conservation District. No date. *The Arroyo Grande Creek Flood Control Channel: History and Current Challenges*. http://www.coastalrcd.org/zone1-1a/Scope%20of%20Work%20for%20Alt%20Study_files/ag_ck_history.pdf

Coastal San Luis Resource Conservation District. 2011. *Final Report for the Pismo Creek Estuary Enhancement Project*. Prepared for California Department of Parks and Recreation, Oceano Dunes District. June 2011.

Coyne, M. 2000, *California beach nourishment history*. California Coastal Commission and California Department of Boating and Waterways, unpublished spreadsheet of compiled data on beach nourishment projects in California. Available from the California CSMW at http://www.dbw.ca.gov/csmw/beach_nourishment.aspx

CO-CAT. 2010. Coastal and Ocean Working Group of Climate Action Team, *State of California Sea level rise Interim Guidance Document*. Sea level rise Task Force of the Coastal and Ocean Working Group of the California Climate Action Team. October 2010.

County of Santa Barbara Public Works. 2015. Water Resources Division, Twitchell Reservoir. http://cosb.countyofsb.org/pwd/pwwater.aspx?id=3732

CSMW, 2002. California Master Plan for Coastal Sediment Management Project Workplan. http://www.dbw.ca.gov/csmw/pdf/CCSMMP_Workplan16.pdf

CSMW, 2010. California Beach Erosion Assessment Survey 2010.

CSMW, 2012. The California Coastal Sediment Master Plan Status Report, prepared by the California Coastal Sediment Management Workgroup. http://www.dbw.ca.gov/csmw/pdf/SMPJune_2012_StatusReport.pdf. June 2012

CSMW. 2015. Coastal Sediment Management Workgroup, CSMW WebMapper and Spatial Data Database. http://www.dbw.ca.gov/csmw/, March 2, 2015.

DNOD, 1977. *Assessment and Atlas of Shoreline Erosion along the California Coast*. State of California – Department of Navigation and Ocean July 1977.

Dingler, J.R., Anima, R.J., Molzan, D.E., Gretchen Luepka, G., and Peterson, C.L.. 1982. *A Field Study of Littoral Processes in Estero Bay, California*. Department of the Interior, United States Geological Survey. Open-File Report 82-537. Menlo Park, California. June, 1982.

EIC, 2006. Calkifornia Coastal Sediment Master Plan, Beach Restoration Regulatory Guide. Prepared for the California State Coastal conservancy and Coastal Sediment Management Workgroup. Everest International Consultants, Inc. December 2006

Everts Coastal. 2000. *Year-2000 Sediment Management Tactic Port San Luis*. Prepared for Port San Luis. January 11, 2000

FEMA. 2015a. Coastal Hazard Analysis Modeling Program, Version 2.0. Federal Emergency Management Agency. Flood Hazard Mapping. http://www.fema.gov/coastal-hazard-analysis-modeling-program-version-20. June 12, 2015.

FEMA. 2015b. Risk Mapping Assessment and Planning (Risk MAP). Federal Emergency Management Agency, https://www.fema.gov/risk-mapping-assessment-and-planning-risk-map. Online mapping at http://riskmapprogress.msc.fema.gov/ August 14, 2015.

Foster, M.S. and Schiel, D.R.. 1985 . The Ecology of Giant Kelp Forests in California: A Community Profile. U.S. Fish and Wildlife Service Biological Report, 85(7.2): 1-152.

Google Earth Pro, 2015. https://www.google.com/earth/explore/products/desktop.html. [access date]

Griggs, G., 1998, *California's Coastline: El Niño, Erosion and Protection*, *in* California's Coastal Natural Hazards: Santa Barbara, California, University of Southern California Sea Grant Program 36, 36-55 (L. Ewing & D. Sherman eds., 1998).

Griggs, G., Pepper, J.E., and Jordan, M.E., 1992. "California's Coastal Hazards: A Critical Assessment of Existing Land-Use Policies and Practices." California Policy Seminar Report. University of California.

Griggs, G., Patsch, K., and Savoy. L., 2005. *Living with the Changing California Coast*. Sponsored by the National Audubon Society.

Hammar-Klose, E. and Thieler, E.R., 2001. Coastal Vulnerability to Sea level rise: A Preliminary Database for the U.S. Atlantic, Pacific and Gulf of Mexico Coasts U.S. Geological Survey Digital Data Series – 68. Data available on Coastal Change Hazards Portal. http://marine.usgs.gov/coastalchangehazardsportal/

Hapke, C.J., Reid, D., Richmond, B.M., Ruggiero, P., and List, J., 2006. *National Assessment Of Shoreline Change Part 3: Historical Shoreline Change and Associated Coastal Land Loss Along Sandy Shorelines of the California Coast*. Part of the U.S. Geological Survey National Assessment of Shoreline Change http://pubs.usgs.gov/of/2006/1219/ and http://coastal.er.usgs.gov/shoreline-change/

Heberger, M., Cooley, H., Herrera, P., Gleick, P.H., and Moore, E., 2009. *The Impacts of Sea-Level-Rise on the California Coast*. A Paper From: California Climate Change Center. CEC-500-2009-024-F. May 2009.

Higgins, C.T., Downey, C.I., and Clinkenbeard, J.P., 2004. *Literature Search and Review of Selected Topics Related to Coastal Processes, Features, and Issues in California.* Prepared for the California Coastal Sediment Management Workgroup by the California Geological Survey.

IPCC, 2007

Kent, L. K., Magoon, O.T., and Richmond, A., 2005. "Market Incentives that Starve Our Beaches: Gainers and Losers." *Coastal Disasters 2005*. ASCE.

King, P. 1999. The Fiscal Impact of California Beaches, A report commissioned by the California Department of Boating and Waterways. Public Research Institute, San Francisco State University 1999.

King, P., & McGregor, A. 2012. Who's Counting: An Analysis of Beach Attendance Estimates in Southern California. Prepared for the California Department of Boating and Waterways.

Mantua and Hare, 2002

Martin, L.R. 2005. *Regional Sediment Management (RSM)*. MS PowerPoint presentation. USACE, Institute for Water Resources. June, 2005.

MBNEP, 2011. Morro Bay National Estuary Program. Morro Bay Sediment Loading Update. December 2011.

MBNEP, 2012. Morro Bay National Estuary Program, Comprehensive Conservation Management Plan (CCMP) 2012 Update.

MBNMS. 2014. MBNMS Site Characterization, Biological Communities: Marine Mammals. Monterey Bay National Marine Sanctuary http://montereybay.noaa.gov/sitechar/mammt2.html

Moffatt and Nichol, 2006. Sand Compatibility and Opportunistic Use Program Plan. Prepared for SANDAG and California coastal Sediment Management Workgroup. March 2006

NOAA. 1992. Monterey Bay National Marine Sanctuary Final Environmental Impact Statement Management Plan. National Oceanic and Atmospheric Administration, Available at: http://montereybay.noaa.gov/intro/mp/archive/original_eis/partII_sII.html.

NRC, 1985. Dredging Coastal Ports: An Assessment of the Issues. National Research Council National Academy Press, Washington, D.C. pp. 117-139.

NRC, 1987.

NRC. 1995. Beach Nourishment and Protection. National Research Council National Academy Press, Washington, D.C. 334 pp.

NRC, 2012. *Sea level rise for the Coasts of California, Oregon, and Washington: Past, Present and Future*. National Research Council. The National Academies Press. 2012

NOAA. 2015. *Sea Level Rise and Coastal Flooding Impacts, Sea Level Rise Viewer*. Digital Coast, National Oceanic and Atmospheric Administration, Office for Coastal Management. http://coast.noaa.gov/slr/

NMFS. 1991. Southern California Eelgrass Mitigation Policy. National Marine Fisheries Service (1991, Revision 11). R.S. Hoffman, ed.

NMFS. 2008. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Pacific Fishery Management Council. National Marine Fisheries Service, July 2008.

NMFS. 2011. Coastal Pelagic Species Fishery Management Plan. National Marine Fisheries Service, September 2011. Available at: http://www.pcouncil.org/wp-content/uploads/CPS_FMP_as_Amended_thru_A13_current.pdf.

NMFS. 2012. Southern California Steelhead Recovery Plan Summary, National Marine Fisheries Service.

NMFS and USFWS, 1998. Leatherback Turtle Recovery Plan. National Marine Fisheries Service and United States Fish and Wildlife Service. Available at: http://www.nmfs.noaa.gov/pr/pdfs/recovery/turtle_leatherback_pacific.pdf

OMR. 2015. Interactive Map. Office of Mine Reclamation, California Department of Conservation. http://maps.conservation.ca.gov/mol/mol-app.html

Orme, et al, 2011.

Pacific Institute. 2009. Impacts of Sea Level Rise on the California Coast. A paper from California Climate Change Center. http://www2.pacinst.org/reports/sea_level_rise/gmap.html May 2009.

Patsch, K. and Griggs, G.,., 2006. "Littoral Cells, Sand Budgets, and Beaches: Understanding California's Shoreline". Institute of Marine Sciences, University of California, Santa Cruz, in Conjunction with California Department of Boating and Waterways and Coastal Sediment Management Workgroup

Peterson, C.H. and Bishop M.J., 2005. Assessing the environmental impacts of beach nourishment. BioScience 55(10):857-896.

PFMC. 1997. Pacific Coast Salmon Plan – Fishery Management Plan of Commercial and Recreational Salmon Fisheries off the coasts of Washington, Oregon, and California as revised in 1996 and implemented in 1997. Pacific Fishery Management Council

PFMC. 2014. Appendix A Pacific Coast Salmon EFH. Pacific Fishery Management Council

Philip Williams & Associates (PWA); Thorton, E; Dugan, J; and Halcrow Group (2008). *Coastal Regional Sediment Management Plan for Southern Monterey Bay.* Prepared for Association of Monterey Bay Area Governments (AMBAG). Available at: http://www.dbw.ca.gov/csmw/pdf/SMontereyBay_CRSMP_3Nov2008.pdf

Philip Williams & Associates (PWA) (2009). *California Coastal Erosion Response to Sea level rise - Analysis and Mapping*. Prepared for the Pacific Institute.

PWA, 2012. Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay. Prepared for Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. May 2012

Revell and Griggs, 2006

Russell and Griggs, 2006

Richmond, J.A., Magoon, O.T., and Edge, B.L., 2007. "Where's the Sand? Reduction in the Delivery of Sediment to Coastlines," *Proceedings of Coastal Zone 07*. July 2007.

SAIC. 2006. Coastal Habitat Study, 2003-2005: Influence of Beach Nourishment on Biological Resources at Beaches in the City of Encinitas, California. Prepared for City of Encinitas.

San Luis Obispo County. 2001. *San Luis Obispo County LCP Periodic Review*. Section 7, Coastal Hazards. http://www.coastal.ca.gov/recap/slosum.html July 12, 2001.

San Luis Obispo County Air Pollution Control District. 2010. *South County Phase 2 Particulate Study, Executive Summary*. February 2010.

San Luis Obispo Regional Water Management Group, 2014. *San Luis Obispo Integrated Regional Water Management Plan*. San Luis Obispo County, July 2014.

Santozo et al, 2013.

Seymour, R. J., 1998, Effects of El Niños on the west coast wave climate. *Shore and Beach*, Vol. 66, No. 3, pp. 3 - 6.

Simms, A.E. 2010 Atlas of Sensitive Species of the Morro Bay National Estuary Program, Morro Bay, California, and California Department of Parks and Recreation, San Luis Obispo Coast District, San Simeon.

SIO. 2004. Santa Maria Cell. Scripps Institution of Oceanography http://coastalchange.ucsd.edu/st1_thenandnow/maria.html

SLO County Water, 2016. San Luis Obispo County Water Resources, Division of Public Works. http://www.slocountywater.org/site/Water%20Resources/Data/Reservoirs/Lopez/. Accessed January 2016

Storlazzi, C. D., C. M. Willis and G. B. Griggs (2000). Comparative Impacts of the 1982-83 and 1997-98 El Niño Winters on the Central California Coast, *Journal of Coastal Research* Vol. 16, No. 4., pp. 1022-1036.

Storlazzi, C. D. and D. K. Wingfield (2005). *The Spatial and Temporal Variability in Oceanograhic and Meterorologic Forcing along Central California: 1980-2002: USGS Scientific Investigations Report, 2005-5085.*Surfrider Foundation. 2014. *State of the Beach Report* via website "Beachapedia". http://www.beachapedia.org/State_of_the_Beach/State_Reports/CA/Surfing_Areas

Swanson Hydrology + Geomorphology. 2006. *Final Arroyo Grande Creek Erosion, Sedimentation and Flooding Alternatives Study.* Prepared for Coastal San Luis Resource Conservation District. January 4, 2006

USACE. 1991. *Feasibility Report: Morro Bay Harbor, San Luis Obispo County, CA, Volume 1, Main Report, Environmental Assessment, Final*. U.S. Army Corps of Engineers, Los Angeles District. August 1991.

----. 2003. *Morro Bay Estuary City of Morro Bay, San Luis Obispo County, CA Ecosystem Restoration Feasibility Study Draft F3 Conference Report Without-Project Conditions Analysis*. US Army Corps of Engineers, Los Angeles District . July 15, 2003.

----. 2005. *USACE – Los Angeles District Coastal Planning Program*. US Army Corps of Engineers, Los Angeles District May 2005.

----. 2006. Regional General Permit Number 67, Discharges of Dredged or Upland-Derived Fill Materials for Beach Nourishment Projects. U.S. Army Corps of Engineers, Los Angeles District, September 25, 2006.

----. 2008. *Pismo Beach, CA Shoreline CAP 103 Study Project Management Plan*. US Army Corps of Engineers, Los Angeles District, September 2008

----, 2011. *Engineer Circular 1165-2-212: Sea-Level Change Considerations for Civil Works Programs*: http://publications.usace.army.mil/publications/eng-circulars/EC_1165-2-212.pdf. Department of the Army, Washington, DC 20314-1000.

----. 2013. Orange County Coastal Regional Sediment Management Plan. Prepared by Everest International Consultants, Inc. U.S. Army Corps of Engineers, Los Angeles District June, 2013.

----. 2014a. *Final Environmental Assessment Morro Bay Size Year Federal Maintenance Dredging Program Hopper Dredge Operations*. U.S. Army Corps of Engineers Los Angeles District. May 2014.

----. 2014b. *Review Plan, Pismo Beach CAP 103 Shoreline Protection Study*. U.S. Army Corps of Engineers, Los Angeles District. May 2014.

----, 2015a. [Glossary, section 1.2]

USACE. 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing. U.S. Army Corps of Engineers

----. 2015b. List of Morro Bay Dredging History. Provided by Mr. Joe Johnson, US Army Corps of Engineers, Los Angeles District

----. 2015c. Morro Bay Dredging History. E-mail from Heather Schlosser, US Army Corps of Engineers, Los Angeles District September 30, 2015.

USGS. 2015. Coastal Storm Modeling System: CoSMoS. U.S. Department of the Interior, U.S. Geological Survey. http://walrus.wr.usgs.gov/coastal_processes/cosmos/. July 6, 2015.

Zoulas and Orme, 2007